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HC144R1070

MODEL WIND TUNNEL TESTS OF A REVERSE VELOCITY ROTOR SYSTEM

FINAL REPORT
BY

J.R. Ewans
and
T.A. Krauss

Prepared for Naval Air Systems Command
Under Contract No. N00019-71-C-0506

BY

FAIRCHILD

Fairchild Republic Division Farmingdale, New York 11735

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TEST & EVALUATION
DATE: January 31, 1973

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The authors wish to acknowledge the work performed by staff at other organizations, namely, Naval Air Systems Command, National Aeronautics and Space Administration (Ames Research Center and Langley Research Center), Arnold Research Organization, and by their colleagues at Fairchild Republic.

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SUMMARY

Contract No. N00019-71-C-0506 was awarded in July 1971 to Republic Aviation Division of Fairchild Hiller Corporation to cover the design, manufacture and test of a one-seventh scale reverse velocity rotor system with the goal of substantiating the results that had been predicted for this system in previous analytical studies. Additionally, two-dimensional wind tunnel tests were made on three airfoil sections of the model rotor blade to give data for comparison of the measured performance with that predicted.

The 8 ft diameter 4 bladed model rotor was provided with remote operation of the controls and shaft angle. The hydraulic drive system permitted both normal powered operation and braking of the rotor. Tests were conducted in the 12 ft pressure wind tunnel at NASA Ames during June and July 1972. The tests did not cover the whole range of conditions desired, but results were obtained at advance ratios from 0.3 to 2.46 and at tunnel speeds up to 350 knots.

Significant results of the tests were the freedom of the rotor from instability, and the ability to trim the rotor laterally and longitudinally under all conditions.

After allowance had been made for the effect of Reynolds number, the performance of the model rotor was found to be similar to that predicted in the previous analytical studies and to further predictions based on the two-dimensional model airfoil tests. The rotor response to control angle was greater than predicted at high advance ratios; however, the effective lift/drag ratios were generally in good agreement.

It is recommended that further tests be performed with this model to expand the envelope of test conditions, particularly to include testing with two-per-rev control angle input.

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LIST OF SYMBOLS

a	Linear lift curve slope
b	Number of blades
c	Rotor blade chord, inches
c_b, c_ℓ, c_m	Airfoil section camber
C_d	Airfoil section drag coefficient
C_l	Airfoil section lift coefficient
C_m	Airfoil section moment coefficient
C_D or C_{D_R}	Rotor drag coefficient = $D/\pi \rho R^4 \Omega^2$
C_H	Rotor H - force coefficient = $H/\pi \rho R^4 \Omega^2$
C_L or C_{L_R}	Rotor lift coefficient = $L/\pi \rho R^4 \Omega^2$
C_M	Moment coefficient
C_Q	Rotor torque coefficient = $Q/\pi \rho R^5 \Omega^2$
C_T	Rotor thrust coefficient = $T/\pi \rho R^4 \Omega^2$
C_X	Coefficient of X force
C_Z	Coefficient of Z force
D	Rotor drag force in flight coordinate system, positive aft, lbs
D_E	Equivalent drag force of rotor, lbs
e_β	Spanwise offset of flapping hinge from centerline of rotation, feet
g	Acceleration due to gravity, ft/sec^2
H	Longitudinal component of rotor resultant force in shaft axis system, positive aft, lb
I_β	Blade mass moment of inertia about flap hinge, slug-ft^2
K_β	Angular spring rate about flapping hinge, in-lb/rad.
K_θ	Angular spring rate about blade pitch axis, in-lb/rad.

L	Rotor lift, flight coordinate axis, lbs
M	Mach number
P_t	Wind tunnel total pressure
q	Dynamic pressure = $\frac{1}{2}\rho V^2$, lb/ft^2
Q	Steady rotor torque, ft-lb
r	Airfoil section radius
R	Rotor blade radius, ft
R or RN	Reynolds number
t	Airfoil maximum thickness, inches
T	Rotor thrust, shaft axis, positive up, lb
V	Forward velocity of aircraft, ft/sec
W	Aircraft gross weight, lb
x	Non-dimensional blade station from centerline of rotation
X	Rotor propulsive force, positive aft, lb
y	Non-dimensional blade distances normal to the blade chord
α	Local blade element aerodynamic angle of attack, degrees = $\theta - \phi$
α_{CA}	Control axis angle with respect to normal to flight velocity ($= \alpha_s + \theta_{1s}$)
α_s	Aft tilt angle of rotor shaft with respect to normal to flight velocity vector, deg
α_{TPP}	Inclination of rotor tip path plane to wind axis, positive aft
β	Blade flapping angle with respect to normal to shaft, positive up, deg
β_o	Rotor coning angle
β_{1c}	1st harmonic longitudinal flap angle
β_{1s}	1st harmonic lateral flap angle
γ	Blade Lock number $= \rho$ ac R^4/I_β

δ_3	Pitch-flap coupling angle
θ	Blade pitch angle, positive nose up, deg
θ_o	Collective pitch angle at centerline of rotation, deg
θ_t	Blade linear built-in twist angle, deg
θ_{1c}	1st harmonic lateral cyclic pitch angle, deg
θ_{1s}	1st harmonic longitudinal cyclic pitch angle, deg
θ_{75}	Collective pitch angle at 75% blade radius = $\theta_o + .75\,\theta_t$, deg
μ	Rotor advance ratio = $V \cos \alpha_s / R\,\Omega$
ρ	Air density, slug/ft^3
σ	Rotor solidity ratio, = $bc/\pi R$
σ_β	Static moment of blade about flapping hinge, slug-ft
Ψ	Blade azimuth angle measured in direction of rotation from aft position, deg
Ω	Rotor angular velocity, rad/sec

1. INTRODUCTION

1.1 The Reverse Velocity Rotor Concept

Present day helicopters are speed limited due to three effects, namely stalling of the tip of the retreating blade, loss of lift due to reverse flow over the inboard part of the retreating blade and compressibility on the tip of the advancing blade.

The Reverse Velocity Rotor System is designed to remove these limitations and make possible cruising speeds up to 350 knots. At high forward speeds the rotor is slowed so that the flow on the retreating blade is reversed and lift is generated with a negative pitch angle making a positive angle of attack to the reverse flow. At the same time the velocity at the tip of the advancing blade is reduced so that compressibility effects are considerably reduced or avoided. Since the rotor blades are required to operate in reverse flow, a "reversible" airfoil section is used having a rounded trailing edge to give reasonable lift and drag characteristics in reverse flow.

In the regiou where appreciable mixed flow exists on the retreating blade (advance ratios from .4 to 1.0), a twice-per-revolution cyclic input of control angle to the rotor blades control system is utilized to control the lift distribution around the aximuth.

The three essential components of the reverse velocity concept are therefore:

a) Reduced rotor rpm at high forward speed
b) Rotor blade airfoil section suitable for reverse flow
c) Higher harmonic feathering

Except in hover and low speed forward flight, the rotor of a RVR helicopter will operate in or near to an auto-rotative condition with auxiliary propulsion of the vehicle.

1.2 Previous Work

A theoretical feasibility study (designated Phase I) of the RVR rotor system was performed by Fairchild under contract from Naval Air Systems Command. The Phase I study covered rotor performance, rotor blade stability, rotor control, and preliminary design of RVR vehicles and is reported in Reference 1. It was concluded

in this report that development of the system appeared feasible and that the achievable performance level would be satisfactory.

1.3 Purpose of Test

After review of the report, it was concluded that the next step was to confirm these conclusions by model tests in a high speed wind tunnel. This has been designated Phase II, and is the subject of this report.

The main goals of the Phase II test were:

1. Measurement of rotor lift at intermediate advance ratios and the effect of two per rev pitch
2. Measurement of rotor lift-drag ratio at high advance ratios

Other areas to be investigated were:

3. Rotor control characteristics
4. Rotor blade dynamic stability
5. Blade fatigue loads at high advance ratio
6. Windmilling characteristics

An additional requirement of the program was that the rotor blades would be approximately dynamically scaled models of those on a realistic RVR rotor. Because of the possibility of unforeseen rotor blade instabilities at high advance ratios, it was decided that use of a pressure tunnel was desirable; rotor characteristics could be initially determined at low tunnel pressure where instabilities are less likely due to the low Lock numbers in both the torsion and flapping modes. This led to the choice of the 12 foot pressure tunnel at the NASA Ames facility. It was also decided to make the rotor a 1/7 geometrically scaled model of the full scale design developed in Reference 1.

1.4 Description of Model and Test Rig

1.4.1 General

The rotor shaft bearings, the control system and the hydraulic drive system are all mounted on a baseplate carried on a NASA Ames 2.5 in dia. High Endurance Balance, which is in turn mounted in a Y-shaped support frame on a pedestal bolted to the

floor of the tunnel. The support arm is pivoted on the pedestal so that the shaft angle can be varied in the range 5° forward to 15° aft using the wind tunnel incidence gear. The whole unit is enclosed in upper and lower fairings which give clearance for the blades and control system.

Figure 1.1 shows the installation in the NASA Ames 12 ft pressure tunnel. Figure 1.2 is a three-quarter rear view with fairing removed, showing the support frame, balance location, etc.

The whole of the airloads on the blades, hub, hub fairing and on the parts of the control system not shielded by the upper fairing are measured in six components on the balance, the geometric relationship being as shown in Figure 1.3.

1.4.2 Rotor Blades

Blade geometry is given in Table 1.I The rotor blades are of constant chord with a root cutout at 23 percent radius. The Fairchild developed reversible airfoil sections are a 1.5 percent cambered 6% thick section at the tip and a 3.5 percent cambered 18% thick section at the root, with linear taper from root to tip. The method of developing the airfoil sections is given in Appendix A. The airfoil sections at root, tip and mid-span are shown in Figure 1.4 and ordinates for these sections are given in Tables A-II and A-III. Pressure distribution and wake surveys tests were made on two-dimensional models of each of the sections in both forward and reverse flow in the 3 ft by 7 ft Low Turbulence Pressure Tunnel at NASA Langley, and are reported in Appendix C.

The construction of the blades consists of aluminum upper and lower skins with thickness variations chordwise and spanwise formed by chemical milling. A C-spar bonded to the skins over the full span at the chordwise change of thickness is machined integrally with the root end attachment. The skins are bonded to an aluminum wedge at the trailing edge and a bronze wedge at the leading edge which also serves as a balance weight. An aluminum honey-comb core is machined to the internal contour and serves as a shear tie between the upper and lower skins as well as a forming core for the bonding operation. Strain gages were bonded at three spanwise positions on two of the blades.

The rotor blade was designed with maximum torsional stiffness at minimum weight as a prime concern. The bonded metal structure was found to be the minimum cost and minimum risk approach to achieving this. The resulting blade Lock number was 2.3 at sea level which is much less than that of conventional helicopter rotor blades.

The rotor shear center and pitch axis were placed at 27.5 percent chord and the section c.g. near 30 percent chord. This configuration was found to be near optimum from studies of flap-torsion dynamic instability at high advance ratio (See Section 4 of Reference 1). Plots of the rotor blade physical properties are shown in Figures 1.5, 1.6 and 1.7. A comparison of measured and theoretical spanwise variation of bending and torsional stiffness is given in Figures 1.8 and 1.9.

The natural frequency spectrum of the rotor blade modes in a vacuum are shown in Figure 1.10.

1.4.3 Rotor Hub

The rotor hub is a 4-bladed fully articulated type with provisions made for various values of delta-3 feedback; however, due to lack of time only a delta -3 angle of 26.5 degrees was used in this series of tests. The concident flap and lag hinges are positioned at 6.5 percent of the blade radius.

Mechanical damping of the blades is provided about the drag hinge by rotary viscous dampers mounted above the rotor hub. The dampers provide a critical damping of approximately .20 about the lag hinge to minimize the potential of a ground resonance-type instability of the rotor mounted on the flexible balance.

A fiberglass fairing with cut-outs to permit blade flapping is mounted over the hub.

1.4.4 Control System

The control system consists of a conventional three-actuator-controlled swashplate to provide collective and one-per-rev pitch with the actuators set at 90°, 180° and 270°. The actuators are remotely operated with controls both for collective, longitudinal cyclic and lateral cyclic and for individual actuators.

Instead of operating the incidence rods directly, however, the swashplate outer-ring carries four levers which serve for the addition of the two-per-rev input to the swashplate motion. This system was based on the design work done in Section 5 of Reference 1, and is illustrated in Figures 1.11 and 1.12.

The two-per-rev motion is generated by a crank on a shaft driven at twice rotor rpm, then passed through a variable amplitude mechanism to a sleeve between the shaft and the one-per-rev swashplate. At the top of the sleeve is mounted a bearing which permits the non-rotating two-per-rev motion to be made

rotating, and transferred, in the case of two blades directly to the mixing levers and in the case of the other two blades to rocker arms positioned on top of the hub and thence to the mixing levers.

Amplitude of the two-per-rev motion is controlled by a remotely operated D.C. actuator.

Because of the appreciable mass of the vertically oscillating sleeve, two weights are mounted near the base of the rotor shaft and connected to the sleeve through levers to balance out the oscillatory motion.

1.4.5 Drive System

The rotor is driven through a toothed belt by a hydraulic motor mounted on the baseplate; the belt passes around the hydraulic rotor drive pulley (21 teeth), the rotor shaft pulley (60 teeth) and the two-per-rev generator drive pulley (30 teeth). The ratio of hydraulic motor rpm to rotor shaft rpm is 2.857:1 and the ratio of the two-per-rev generator rpm to rotor shaft rpm is 2.0:1. When it is not required to operate the two-per-rev mechanism, a shorter belt can be fitted around the hydraulic motor drive pulley and the rotor shaft pulley only, and the two-per-rev sleeve locked in its central position. The phasing of the two-per-rev input to the main rotor shaft is accomplished by the relationship of the rotor and two-per-rev pulleys; phasing can readily be changed after slackening off the drive belt.

The hydraulic motor is driven by a self-contained hydraulic power pack located outside the wind tunnel shell, consisting of an electric motor, pumps, reservoir, filters, control and relief valves, etc. The power pack can be remotely controlled from the wind tunnel control room. Provision is made for controlled braking of the rotor to prevent overspeeding in the windmilling case, and also for automatic control of rotor speed.

Since the hydraulic motor is mounted on the metric part of the system, connection between it and the pedestal is through pressure-balanced swivel joints. It was not possible to measure any tare effects due to the load path across these swivels and pipes. The swivels also allow for the change of alignment of the hydraulic piping when the rotor shaft angle is altered.

1.4.6 Instrumentation

The rotor blades were fitted with bending bridges measuring flapwise bending stress at 3 blade stations namely: .37, .51 and .71 radius, chosen as the most critical blade stations based on theoretical bending moment distributions calculated over the test spectrum. The gages were mounted internally so as not to affect the airfoil characteristics. Vibratory chordwise blade stresses were monitored by axial strain gage measurements on the lag damper rod linkage which is equivalent to monitoring the root vibratory moment. Though these stresses were monitored primarily as an indication of approaching instability, this moment in conjunction with theoretical chordwise vibratory moment distributions on the blade allowed for monitoring stresses at the critical span stations. Axial strain was measured on the pitch link for purposes of monitoring both control system stresses and blade torsional loads. Bending bridges mounted on flex beams which were deflected by cams were used for monitoring flap angle, lead-lag angle, and pitch angle at the blade root.

All of the above quantities were displayed on oscilloscopes which were triggered from a pulse at zero azimuth position on number 1 blade to indicate the phasing of the response on the scopes; this was of prime importance for efficient trimming of the rotor flapping at each test point. The dynamic information for each was also displayed on an oscillograph during the test as well as recorded on magnetic tape.

Transducers were used to measure hydraulic pressures at the input and output side of the hydraulic motor; this was intended for the purpose of correcting pressure tares; however, tests indicated that this was an insignificant correction.

The positions of the electric actuators which govern the swashplate motion and two-per-rev amplitude were measured using linear potentiometers of infinite resolution. These voltages were read in the control room using indicating millivolt potentiometers or "Imps". The pots were wired and calibrated in terms of collective pitch, longitudinal cyclic pitch, lateral cyclic pitch, and two-per-rev pitch amplitude.

Rotor speed was measured by the voltage output of a D.C. generator driven by the hydraulic motor. A second indication of rotor speed was obtained by using a magnetic pickup triggered by a 30 tooth gear on the rotor shaft; the output was directed to a counter which digitally displayed the RPM.

The voltage output from the NASA balance gages was filtered through the "Imps" so that only the steady values remained; these were displayed in raw form on the "Imps" so that rolling moment at balance, rotor thrust, rotor drag and side force could be monitored during testing. The balance vibratory loads were also displayed on an oscillograph for monitoring of balance stresses and/or resonant conditions.

All the non-vibratory information i.e., rotor speed, steady balance loads, control positions in terms of collective, longitudinal, lateral, and 2/rev amplitude, coning angle, and hydraulic pressures were automatically recorded at each test run on paper tape. The balance data was corrected for the primary interactions on a computer with overnight turn-around time. The rotor behavior was made visible in the control room by means of closed circuit television and the entire test was recorded on video tape.

1.5 Test Procedures

The tests were made in the NASA Ames, 12-foot Pressure Tunnel, a variable density, low turbulence wind tunnel, and covered the range of advance ratios from 0.4 to 2.5 at tunnel speeds from 100 to 350 knots. To develop familiarity with the operation and control of the model, initial tests were made at a tunnel total pressure of approximately 12 inches of mercury (density .0008 slugs per cu ft); later testing was at approximately atmospheric pressure (density .0020 slugs per cu ft).

The first series of tests was made with a dummy balance to explore the behavior of the rotor and the capability of controlling it at advance ratios from 0.14 up to 2.0. No problems were encountered, and the program was continued with a NASA Ames 2-1/2 inch two-plane Mark III balance; this was later replaced by a NASA Ames 2-1/2 inch two-plane high endurance balance. As a result of failures of balance bridges, not all the desired test data was obtained.

In general a run consisted of setting the tunnel pressure, tunnel Mach number, and rotor speed at constant values. The shaft angle was then varied from zero (perpendicular to the free stream velocity) to between 5 degrees forward and 12.5 degrees aft. At each shaft angle various settings of collective pitch were made; at each collective setting longitudinal and lateral cyclic pitch were adjusted to produce zero longitudinal flapping with respect to the shaft and zero rolling moment (the roll axis of the balance is located at approximately the C.G. axis with respect to the rotor center of a realistically scaled helicopter). Thus the shaft angle became the tip path plane angle. The

rolling moment shown on the balance was accurately nulled while longitudinal flapping was kept to within one degree. When two-per-rev pitch was a variable, the same procedure as above was used except that for each collective setting the two-per-rev pitch amplitude was varied and the rotor trimmed as above for each two-per-rev setting.

As shaft angle was increased and/or the rotor controlled to flap backwards, auto-rotative conditions were reached. When the rotor torque was sufficient to overcome the friction of the control and drive systems and the hydraulic losses, the hydraulic braking control was brought into use to prevent overspeeding of the rotor and maintain the desired rpm. By this means testing was continued into the negative torque region.

After the operator had gained experience it was found possible, by operation of the lateral and longitudinal controls, to control rpm around the zero torque region, with the dump-valve opened to by-pass the hydraulic system.

In addition to the six-component balance data, rotor dynamic quantities were also recorded including azimuthal variations of blade lag and flapping motions, blade bending moments and the lag damping moments; these are considered in Section 4.

The usual tunnel corrections used to adjust data for the effects of wall interference have been applied to the data. These conventional wall corrections are expected to be satisfactory for rotor models operating at advance ratios above 0.3. No attempt has been made to account for aerodynamic interference from the model and support fairings.

1.6 Test Conditions

The relationship between wind tunnel speed, rotor rpm and advance ratio for the model rotor is shown in Figures 1.13 and 1.14. On these figures are indicated the values at which tests were made, designated by run number, for 0.40 atmosphere density and 1.0 atmosphere density respectively.

The maximum Reynolds number for the model and full scale blades occurs at the tip of the advancing blade, and has the following values:

full scale rotor blade,	19 million
model blade at approximately atmospheric pressure,	2.4 million
model blade at 40% atmosphere,	1.0 million

1.7 Scheduled Lift Coefficient

The RVR concept requires the reduction of rotor speed as vehicle speed is increased, and the rotor lift coefficient for 1g level flight will therefore vary over the flight regime. Generally speaking, it is desirable to keep the rotor speed up to the limits of maximum rpm or of tip Mach number for advance ratios below unity and to reduce rotor rpm once reverse flow has been fully established over the retreating blade at advance ratios greater than one.

An optimum schedule of rotor rpm has yet to be established, but the following values were assumed for the purpose of interpreting the results of these tests: from the hover, 100% rpm until a tip Mach number of 0.92 is attained; then a progressive reduction of rpm maintaining this Mach number until the forward speed attains 300 knots at an advance ratio of about 1.0; then a reduction of rpm at 300 knots until tip Mach number equals 0.8 at an advance ratio of 1.2; at all higher speeds the tip Mach number is maintained at this value.

The model rotor was sized to carry a 1g scaled lift of 400 lbs corresponding to a disc loading of 8 lb per sq ft. This, in conjunction with the above velocity-rpm schedule, defines the lift coefficient versus advance ratio curve; thus the 1g lift condition can be related to advance ratio alone regardless of the velocity-rpm combination. Figure 1.15 shows this schedule of rotor lift coefficient as a function of advance ratio for this rotor system, assuming sea level standard conditions.

The scheduled velocity-rpm line is shown superimposed on plots of the test data runs in Figure 1.13 for the 40 percent atmosphere runs and Figure 1.14 for the one atmosphere runs. Note that for both tunnel density conditions considerable data was taken that is representative of the scheduled condition in which advance ratio and tip Mach number are both correctly represented.

2. RESULTS - PERFORMANCE

2.1 Aerodynamic Tares

Aerodynamic tares were taken at each tunnel density tested by taking balance readings with rotor blades removed at various tunnel speeds, each time varying shaft angle and rotor speed. The latter had only a small effect on the tares, and an average value has been used in analysis. The tare corrections for force along the balance axis and at right angles to the balance axis and for pitching moment are shown in Figures 2.1, 2.2 and 2.3. Due to failure of the axial component of the balance, X-direction tares were not obtained at high density. The corresponding values from low density (Fig. 2.1) have therefore been used.

The drag tares and lift tares were found in some cases to be a large percentage of the total balance load. Torque tares were found to be negligible.

2.2 Tabulated and Plotted Results

The results for each data point, namely rotor lift, drag, and torque data corrected for weight and aerodynamic tares and the control angles used are presented in Appendix B of this report. For each setting of rotor shaft angle and collective pitch the lateral and longitudinal cyclic pitch were adjusted to produce zero rolling moment about the balance axis and approximately zero longitudinal flapping with respect to the shaft. Points which were not trimmed were identified by investigating the flapping oscillograph traces so that rotor tip path plane could be determined for each run.

For each significant run,rotor lift coefficient,effective lift/drag ratio, torque coefficient and drag coefficient have been plotted versus collective pitch for constant tip path plane angles in Figures 2.4 through 2.24.

2.3 Rotor Lift

For each advance ratio the 1g lift coefficient level obtained from Figure 1.15 has been indicated on the lift coefficient curves of Figures 2.4 through 2.24. The exact requirements for lifting ability of a high speed rotor system are not fully defined at this stage: for example the airflow over the fuselage, mast fairing and hub will provide appreciable lift on a high speed helicopter. However, if this is neglected, it will be seen that a requirement for 1.3g maneuver capability at a disc loading of 8 lb/sq ft

at sea level standard conditions can be met or exceeded for all advance ratios outside the range of 0.7 to 1.5 without exceeding a tip path plane angle of ten degrees.

Rotor lift coefficient divided by the lift coefficient at 1g conditions was plotted as a function of advance ratio for constant values of control axis angle at constant tip path plane angles of 5 deg and 10 deg in Figures 2.25 and 2.26, respectively. The curves for both values of tip path plane show that for advance ratios below about 1.0, lower values of control axis angle produce more lift; beyond this advance ratio, lift increases with increase of control axis angle. For the 5° tip path plane case, the available lift is seen to drop below the 1g level over a wide range of advance ratios (from .5 to 1.4) for control axis variations between 0 and 7 degrees. When the tip path plane angle is increased to 10 degrees, a disc loading of 8 lb/sq ft can be achieved at all advance ratios.

Theoretical studies have verified this trend and have indicated that for approximately this same control axis range and tip path plane, the addition of moderate values of two-per-rev cosine phased pitch will increase the available lift in laterally trimmed flight to a minimum of 1.3g's over the full advance ratio range for this rotor.

It is noted that the lateral trim requirements were less than 6 degrees for all 1g conditions.

2.4 Rotor Lift-Drag Ratio

Rotor performance can be assessed by the parameter effective lift/drag ratio, defined by converting the total rotor power required into a force and adding to this the rotor drag (or subtracting the rotor propulsive force). In equation form:

$$L/D_E = L/\left(\frac{550\ RHP}{V} + D\right)$$

The effective lift-drag ratio of the rotor blades was computed by subtracting the aerodynamic hub tares from the measured rotor forces and moments and calculating the effective drag due to the combined effect of drag force and rotor torque. For those cases where the rotor torque was negative, i.e., the airloads were tending to speed up rotor, the torque was assumed to be transferred to a usable propulsive system (e.g., tail propeller) at 100 percent efficiency.

It will be seen from Figures 2.4 through 2.24 that at low advance ratios (μ = .29 Fig. 2.16) in the conventional helicopter range, rotor efficiency increases with decreasing tip path plane angle, i. e., as the rotor moves into the propulsive region. Effective lift/drag ratios of 8 were measured, and this is maintained up to advance ratios of at least .46 (Fig. 2.17). In the range of intermediate advance ratios, effective lift/drag ratio falls off to a minimum of about 6 at an advance ratio near 0.8. At higher advance ratios the lift/drag ratio again increases, with a value of 8 at advance ratios of 1.0 through 1.4, and thereafter increasing to the order of 12 at advance ratios above 2.

The maximum achieved values of the effective lift/drag ratio are given in Table 2-I and plotted vs advance ratio in Figure 2.27. The lift coefficients corresponding to these maximum values may not be those for level flight at the assumed rotor disc loading of 8 lb per sq ft, and effective lift/drag ratios at the latter condition are also given in Table 2-I and plotted in Figure 2.28 for the range of advance ratios. Figure 2.29 shows the effect of lift coefficient in detail for an advance ratio of 1.5. In this case better cruise efficiency would have been obtained if a reduced disc loading had been selected. An alternative may be the use of small amounts of two-per-rev control which was shown in reference 1 to have a significant effect on the conditions under which best effective lift/drag ratio was obtained.

2.5 Rotor Torque

Although not essential to the RVR system it is desirable that when operating at reduced rpm the rotor should be in an auto-rotative condition at zero torque. At the same time, the lift must be appropriate to level flight and the rotor trimmed. From figures 2.4 through 2.24 the combination of collective control angle and tip path plane angle that meets these conditions can be determined, and figure 2.30 shows the tip path plane angle for zero torque and a lift coefficient corresponding to the scheduled combination of vehicle speed and rotor rpm for 8 lb/sq ft disk loading as a function of advance ratio. As was shown in figures 2.25 and 2.26, without using two-per-rev control large flapping angles would be required in the advance ratio range of 0.9 to 1.3. Outside this range, however, figure 2.30 shows that zero torque and the scheduled lift coefficient conditions can be met at practical tip path plane angles. At high advance ratios the necessary tip path plane angle decreases rapidly with increase of advance ratio.

The use of two-per-rev control has been shown in Section 2.5 of reference 1 both to increase the lift available at intermediate advance ratios and to provide a control over torque.

2.6 Accuracy

The net value of the lift on the rotor blades is the difference between the total measured lift and the lift on the hub minus the weight of the model. The net value of the drag is the difference between the total measured drag and hub drag. The net values of both the lift and the drag are therefore the differences between two relatively large quantities, and are subject to magnification of any inaccuracies in measurement. In general, the plotted points for lift and effective lift/drag ratio (figures 2.4 through 2.24)show little scatter, but they may be subject to systematic errors, for example the effect of the rotor lift on the flow field around the hub and therefore on hub lift and drag.

3. RESULTS - ROTOR CONTROL

3.1 Control Angle

Figures 3.1 through 3.8 show, for the range of advance ratios, the relationship between control angle, tip path plane and collective pitch with the rotor trimmed laterally at all times. With one exception results are given for the tests at atmospheric tunnel pressure only, since at the reduced tunnel pressure the Lock number is not representative of the full scale rotor. Figure 3.8, however, gives results for tests at low pressure at an advance ratio of 1.4 and may be compared with Figure 3.7 for atmospheric pressure and the same advance ratio.

3.2 Collective Control Power

The relationship between collective control angle and lift coefficient for a trimmed rotor at constant tip path plane can be derived from Figures 2.4 through 2.24. It will be seen that at low advance ratios lift increases with increasing collective pitch at constant tip path plane angle; as advance ratio is increased the slopes of the curves decrease until collective has no effect on lift at an advance ratio of 0.9. Beyond this advance ratio the rotor thrust is seen to decrease with increased collective pitch requiring negative values to achieve the required lift. Figure 3.9 shows a plot of the slope of the lift coefficient vs collective curve as a function of advance ratio for a 5 degree tip path plane. At the proposed high advance ratios corresponding to reverse velocity cruise flight ($\mu > 1.4$) collective may once again be a meaningful control but in the reverse sense than for low advance ratio flight.

3.3 Rotor Sensitivity

As rotor advance ratio is increased, it is well known that the rotor becomes increasingly sensitive to control inputs and gusts. Positive delta-3 (pitch-flap coupling) was determined from previous analytical studies to be effective in reducing this sensitivity and the rotor had provisions for incorporating delta-3 angles of 0, 26.5, and 45 degrees. For this test only the intermediate value of 26.5 degrees was used.

Rotoı sensitivity is shown in Figure 3.10 where the change in tip path plane angle per degree of control axis angle is plotted as a function of advance ratio. It is noted that this is not a pure derivative since lateral cyclic pitch was varied as required to retrim the rolling moment to zero. The curve shows that the derivative approaches unity at low advance ratios as expected for this moderate value of delta-3. At RVR type advance ratios ($\mu > 1.2$) the derivative approaches 2.5 times the low advance ratio value. At higher advance ratios the sensitivity is seen to decrease.

This sensitivity increase is in good agreement with theoretical calculations. The square symbols show theoretical points calculated at various advance ratios for the model rotor. The decrease in sensitivity at high advance ratios is also as predicted by theory. The theoretical predictions calculated beyond the advance ratio range of the test indicate that the tip path plane sensitivity to control axis input continues to decrease so that at an advance ratio of 2.5 the derivative (at constant lateral flapping) reduces to .80 which is near the value at hover.

3.4 Control Phasing

The phasing between the maximum one-per-rev pitch amplitude and the maximum one-per-rev flapping amplitude is a function of the flapping frequency, flap aerodynamic damping and the delta-3 angle. The theoretical phase angle of the rotor at one atmosphere in hover as a function of delta-3 is shown in Figure 3.11. The low Lock number of the model blades provided relatively low critical damping ratios especially in the low density conditions. This coupled with the hinge offset effect on frequency resulted in the following phase angles calculated in hover:

45.7 degrees at one atmosphere density
30.9 degrees at 40% atmosphere density

These low values of phase angle resulted in a strong coupling of the conventional longitudinal and lateral controls. In the low density conditions the conventional longitudinal cyclic control was used primarily to trim rolling moment and the lateral control was used primarily to trim the fore and aft flapping. The control angles required for trim in the low density condition are thus not typical for full scale comparison unless significantly more delta-3 was used on the full scale rotor such that the phase angle calculated in hover approached 30 degrees. The one atmosphere runs should, however, be representative of full scale control.

It should be noted that even with zero pitch-flap coupling the hinge offset effect produces a phase angle of 65 degrees. For practical values of delta-3 (0 to 45 degrees) the phase angle decreases approximately .7 degrees for every 1 degree increase in delta-3.

3.5 Rotor Flapping

Typical traces of rotor flapping at various advance ratios and near trimmed 1g lift coefficients are shown in Figure 3.12. Because of the low Lock number of the model rotor blades, the maximum coning angle encountered at these conditions is quite small. At the low advance ratio condition, the coning and all harmonics of flapping are seen to be negligible with the rotor trimmed normal to the shaft. At the .46 advance ratio, the flapping is seen to be primarily low amplitude and of two-per-rev frequency; coning angle is again almost negligible (less than one degree). At the intermediate advance ratio of .82 the flapping is again primarily two-per-rev though higher harmonics are becoming evident. Finally at the high advance ratio of 1.5 the higher harmonic content is more evident though the primary frequency is two-per-rev; the two-per-rev amplitude is near two degrees and the coning angle is approximately 2.5 degrees.

No detrimental effects of two-per-rev flapping were obvious though amplitudes near 2 degrees which appeared at the high advance ratios may cause local stalling conditions to occur. Since two-per-rev pitch is not required for lift generation at high advance ratios, this control may be useful in trimming out the two-per-rev flapping should it become desirable to do so.

4. RESULTS - ROTOR BLADE DYNAMICS

4.1 Rotor Blade Resonances

Inherent in the RVR concept is a wide variation of rotor speed during operation from hover to cruise flight. In order to predetermine rotor speed ranges which would produce potentially high blade loads, the frequencies of the bending and torsion modes were calculated during the blade design stage using finite element theory including centrifugal stiffening. The results are shown in Figure 1.10. The flap bending modes were of major concern since these modes have frequencies near the low rotor harmonics where the aerodynamic excitation is relatively high.

During the tunnel test the blade flapwise frequencies were determined near each operating condition by varying the rotor speed at a given advance ratio and noting where the flapwise bending vibratory stresses reached a maximum value. The flapwise modes were found to occur at almost exactly the predicted values. Amplification of flapwise bending loads were noted in the following areas; examples of the flap bending moment traces near these conditions are given in Figure 4.1:

- 1670 rpm (100% rpm) — A clear 5/rev frequency was noted in the bending traces which is near where the 3rd flap mode crosses 5/rev frequency.
- 1050 rpm (63% rpm) — A clear 3/rev frequency was noted in the bending traces with high amplitude. This is the rpm where the theoretical 2nd flap mode crosses 3/rev.
- 680 rpm (41% rpm) — At high advance ratio, a 10/rev low amplitude frequency was noted in the bending traces over a narrow rpm range. The theoretical 3rd flap mode is seen to cross 10/rev at this rpm. This was noted at low density conditions where the damping was small.
- 650 rpm (39% rpm) — A 4/rev frequency of relatively high amplitude was noted which is near the rpm where the second flap mode crosses 4/rev.

No appreciable shift in these resonant rpms was noted as advance ratio was changed indicating that the aerodynamic effects even at advance ratios near 2.0 have small

influence on the resonant frequencies. This is an important finding which allows the use of natural frequency spectra (assumed in a vacuum) to pinpoint areas of high blade loads for the complete advance ratio range.

Resonances of the 3rd flap mode with 6, 7, and 8 and 9/rev were not noted because the rpm band to excite these high frequencies is generally small and amplification is not expected unless the model test conditions were very near these points. Even when operating continually right on the high amplitude 1050 rpm at high advance ratio and high lift coefficient, the bending stresses were less than double the very conservative endurance limit placed on the dynamically scaled blades.

No resonances or amplification were noted in the chordwise vibratory stresses (as noted by the damper arm load) nor were any expected since the chordwise modes only cross integer rpm multiples above 9/rev in the operating range. (See Figure 1.10). No data on resonance of the torsional mode is available.

4.2 Vibratory Flapwise Bending Stresses

Vibratory bending stresses increase substantially with advance ratio due to the increased aerodynamic excitation caused by the complex flow field. To demonstrate this, data runs at 1g lift coefficient were chosen at a constant non-resonant rotor speed of 830 rpm. Thus, the effect of resonant amplification was held constant at various advance ratios. The vibratory bending moments at the 3 spanwise strain gage locations are shown in Figure 4.2. These are from the low density runs where there was sufficient data at constant rotor speed; thus, although the magnitude of the moments are not meaningful, the trend with advance ratio should be representative.

The curves show that as advance ratio is increased from that of present day helicopter limits ($\mu >$ .4) to the high advance ratios required for RVR flight, the bending moments increase by a factor of over 3 for all gage locations. The bending moment is seen to at first increase most rapidly at the inboard station. At the high advance ratios the inboard moments level out and the center span bending moments also begin to do the same. The outboard moments however are seen to increase even more rapidly.

This trend is similar to that predicted by theoretical analysis. Figure 4.3 shows plots of typical estimated spanwise distributions of flapwise vibratory moment

for a blade similar to the model rotor blades tested. Because the moments are calculated at different non-resonant rotor speeds and different air density than used in Figure 4.2, no scale is shown on the ordinate. The distributions show a rapid increase in bending moment as advance ratio is increased from .4 to .7 at the inboard end. At the 1.4 advance ratio condition the inboard moment (.37R) is seen to drop slightly, a small increase occurs in the center location (.51R) and very significant increase in the outboard moment. This may be due to the increasing amount of reverse flow on the outboard part of the span at the higher advance ratios.

To obtain realistic scaled rotor blade loads over the proposed advance ratio range, runs were selected near sea level atmosphere conditions so that aerodynamic damping effects would be realistic. Data runs were also chosen near the scheduled rotor speed condition for each given advance ratio so that near resonant rpm effects would be represented. The moments at the center and outboard stations are shown in Figure 4.4; the inboard bending gage output was not available for all the conditions investigated and is not plotted.

The full scale moments show the near resonant condition at $\mu = 1.0$ (1170 rpm near 1/3 the frequency of the 2nd flap mode) produces more amplification in the outboard gage than the center gages (though this is not evident from the normalized mode moment shape).

5. THEORETICAL PREDICTION OF ROTOR PERFORMANCE AND COMPARISON WITH TEST RESULTS

5.1 Airfoil Section Data

The airfoil sections at the root, mid-span and tip of the model rotor blades were tested in both forward and reverse flow over a range of Reynolds numbers at low Mach number in the Langley Low Turbulence Pressure Tunnel. The tests are described and the results given in Appendix C.

The approximate maximum Reynolds number values appropriate to the model and full scale conditions achieved on the tip of the advancing blade are as follows:

Model tests, average density .00086 slugs/ft^3:	1.0 million
Model tests, average density .00212 slugs/ft^3:	2.4 million
Full scale, sea level density .002378 slugs/ft^3:	20 million

In the performance prediction program, to avoid the complication of tables of aerodynamic data dependent on Reynolds number as well as Mach number, aerodynamic data has been selected according to average Reynolds numbers appropriate to the condition in which the blade section is operating. For the comparison with the model test results, section drag coefficients, which have a greater effect on rotor performance at the higher rotor speeds and reduced angles of attack, were selected appropriate to the Reynolds number range of 1.0 to 2.0 million. The slope of the curve of section lift coefficient was found to vary only slightly with Reynolds number, and was obtained from data at 1 million. When blade sections are operating near maximum lift, they will be at reduced velocity and therefore at reduced Reynolds number - values appropriate to a Reynolds number of 0.4 million were selected.

For the prediction of full scale rotor performance it was indicated that there will be little or no variation of either lift or drag data above a Reynolds number of 12 million and data measured at this Reynolds number was therefore used.

After determining the data to be used at low Mach number and over the angle of attack range tested, it is necessary to extend it to cover all Mach numbers up to 0.92 and for the full angle of attack range of 360 degrees. This was done by the methods of reference 1, and using data from reference 2. The lift and drag coefficients so determined for the 6%, 12% and 18% sections are given in Appendix D.

For the purpose of selecting the aerodynamic data to be used in the rotor performance prediction program, the rotor blade was divided into five equal spanwise units. The data for 6%, 12% and 18% sections was therefore interpolated on a linear basis to give data for 7.2%, 9.6%, 12%, 14.4% and 16.8% sections.

5.2 Performance Prediction

The Fairchild rotor performance computation program ("Aero") has been improved in detail, but is substantially as described in Appendix "B" of reference 1. For the purpose of comparisons with model tests, the "low Reynolds number data" as described in Section 5.1 was utilized, together with the geometric characteristics of the model rotor as given in Table 1-I. The air density, rpm, tunnel speed and speed of sound corresponding to the mean value of a particular run have been utilized, and the program run at a matrix of values of collective pitch angle and control angle, with the rotor balanced to be in lateral trim. Since previous work had shown that the effect of shaft angle with an articulated rotor was small, this was neglected.

The results of these calculations are plotted in Figures 5.1 through 5.12.

5.3 Comparison of Predicted and Measured Results

Initially, comparison was made between the values of tip path plane angle, rotor lift coefficient and equivalent lift/drag ratio measured and calculated at the same values of collective and longitudinal control angles, assuming the rotor to be trimmed laterally in both cases. There is good agreement at low advance ratios, (see figure 5.1) but not at intermediate and high advance ratios; this may be due to a number of factors, for example, changes in velocity and flow direction caused by the presence of the upper fairing. It was found that a better basis for comparison was equivalent lift/drag ratio versus rotor lift coefficient, and this has been used in Figures 5.2 through 5.12.

The maximum values of equivalent lift/drag ratio for both measured and predicted conditions obtained from Figures 5.2 through 5.12 have been plotted in Figure 5.13. Agreement is good in the advance ratio range of 0.5 to 1.0. One cause of the differences at lower and higher advance ratios may be that although in the case of the predicted data sufficient combinations of collective pitch and control angles were utilized to give certainty that the peak value had been obtained, the tests may not have been made at the conditions that would give a maximum. A further cause of difference is

the aerodynamic data; while that at low Mach number had been based on comprehensive tests on the three airfoil sections at the Reynolds number conditions of the model rotor tests (data reported in Appendix C), the effects of Mach number were estimated. Comparing the measured and predicted values at an advance ratio of .45 where the advancing blade tip Mach number is .89 indicates that the extent of the drag rise on the tip section may have been over-estimated.

At higher advance ratios the amount of experimental data is limited and the results scattered; nevertheless it can be seen that the prediction method overestimates rotor performance. This can be corrected by reducing the optional cutoff of maximum lift coefficient in radial flow which is an input to the prediction program.

5.4 Effect of Reynolds Number on Rotor Performance

The prediction of rotor performance was repeated for the same cases that were used in the comparison of the preceding paragraph, but using the full-scale Reynolds number data that were developed from the model airfoil section tests and presented in Appendix D, Figures D19 through D36. Again the span was divided into five sections with data corresponding to thickness-chord ratios of 16.8%, 14.4%, 12.0%, 9.6% and 7.2%. The values of maximum effective lift/drag ratio that were obtained are plotted in Figure 5.14 and compared with the corresponding values for low Reynolds number obtained from Figure 5.13.

It will be seen that at intermediate and high advance ratios the effect of Reynolds number is very considerable. This is due both to the reduction of drag of the airfoil section and the increase in lift at large angles of attack; the latter enables the rotor to operate at a smaller flapping angle for the same thrust.

5.5 Full Scale Rotor Performance

The best curve through the measured points (Table 2-I and Fig. 5.13) has been modified for the predicted effect of Reynolds number (Fig. 5.14) to give the expected full scale performance of a rotor having both the scaled-up physical characteristics and the aerodynamic sections of the model rotor. This is presented in Figure 5.15, which shows the maximum effective lift/drag ratio and the effective lift/drag ratio at a disk loading of 8 lb per sq ft.

5.6 Comparison with Previous Performance Prediction

Figure 5.16 compares the performance now expected for a full scale reverse velocity rotor having the characteristics of the model rotor with the results obtained in previous predictions (Figure 2.38 of reference 1), corrected to be at zero two-per-rev. The characteristics of the two rotors are compared in Table 5-I. In the range of advance ratio from 0.6 to 1.6 the performance of the reference 1 rotor is slightly better. In order to investigate this further, the effect of specific differences between the rotors was predicted.

Performance runs were made with the physical dimensions and aerodynamic data of the rotor number 2 of Table 2-I of reference 1, which will be referred to as "1039" rotor, and with specific variations of characteristics. The results for the basic "1039" rotor operated with zero two-per-rev and a thrust of 20,000 lbs are given in Figure 5.16 for the eight cases considered in reference 1 as follows:

Case	Speed Knots	RPM	Advance Ratio	Fig. of Ref 1
1	250	91%	.66	2.29
2	250	80%	.75	2.30
3	250	60%	1.005	2.31
4	300	80%	.92	2.32
5	300	60%	1.21	2.33
6	300	50%	1.41	2.34
7	350	60%	1.407	2.35
8	350	50%	1.689	2.36

In each case the calculations were performed for three values of control angle and the results given for the optimum control angle.

The effect of individual changes to the following parameters was investigated for cases 2, 5, 6 and 8 of the above table.

- Delta 3, from zero to 26.5 degrees
- Lock number per blade from 6.0 to 3.0
- Atmospheric conditions, from 91.5°F and 3000 ft to standard sea level conditions (59°F) changing density from .001998 slugs/ft^3 to .002378 slugs/ft^3 and the speed of sound from 1150 ft/sec to 1117 ft/sec. (Note that a change of density also changes the Lock number.)

The results are shown in Figure 5.17. As might be expected, the purely geometrical change of delta-3 has no effect on rotor performance. Both the reduction in altitude and the increase of blade inertia cause a significant improvement in rotor performance, with the exception that at 350 knots the increase of Mach number on the tip of the advancing blade causes a loss of performance. The combined effect of all three changes is also shown in Figure 5.17.

It would appear from this that the cause of differences in performance shown in Figure 5.16 must be due to differences in the aerodynamic data.

6. CONCLUSIONS AND RECOMMENDATIONS

The tests conducted on a model 8 ft diameter 4-blade rotor with reversible airfoil sections demonstrated that it could be operated satisfactorily at advance ratios up to 2.5 and speeds up to 350 knots. Control was maintained throughout by conventional controls, both in power, in free auto-rotation and in the braking modes. Operation was free of dynamic instability.

Two-dimensional tests were performed over a range of Reynolds numbers on the root, mid-span and tip airfoil sections of the rotor blades to give data for the prediction of the rotor performance using the Fairchild rotor performance program. When using airfoil data appropriate to the Reynolds number of the model tests, there was generally good agreement between measured and predicted effective lift/drag ratio. With data appropriate to full-scale Reynolds numbers, a substantial improvement in effective lift/drag ratio was predicted. It appears from this and from the results of the estimates made of other changes in rotor characteristics that the overall rotor performance is sensitive to the properties of the airfoil sections selected for the blade.

It is recommended that further tests be conducted with this model to more completely cover the range of test conditions, and to include testing with two-per-rev blade pitch angle input. A comprehensive study of the effect of airfoil section on rotor performance leading to the selection of optimum rotor blade sections along the span is considered an essential step before proceeding to the development of a full scale rotor.

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REFERENCES

1. Staff of Fairchild Republic Division, Analytical Study of the Reverse Velocity Rotor System, Fairchild HC122R1039, October 1971.

2. W. H. Tanner, Charts fo. Estimating Rotary Wing Performance in Hover and at High Forward Speeds, NASA CR-114, November 1964.

TABLE 1-I. ROTOR CHARACTERISTICS

Item	Value
Scaled Vehicle Gross Weight	400 lb
Disk Loading	8.0 lb/sq ft
Solidity	.133
Hover Tip Speed	700 ft/sec
Number of Blades	4
Rotor Radius	48.36 in.
Blade Chord (Constant)	5.0 in.
Blade Linear Twist	0
Root Cutoff/Blade Radius	.23
Flapping Inertia per Blade	2972 lb/in.^{2}
Flapping Moment per Blade	132 lb/in.
Torsional Inertia per Blade	5.0 lb/in.^{2}
Lock Number (sea level atmosphere)	2.3
Lag Hinge Offset/Rotor Radius	.065
Pitch Flap Coupling Angle - Delta-3	26.5 deg*

* Other values available were not used during this test program.

TABLE 2-I. MEASURED EFFECTIVE LIFT-DRAG RATIOS
(See Figures 2.27 and 2.28)

Figure No.	Advance Ratio	Maximum L/D_E L/D_E	Maximum L/D_E At α_{TPP}	At Disc Loading = 8 lb/sq ft L/D_E	At Disc Loading = 8 lb/sq ft At α_{TPP}
Low Density					
2.4	.46	6.4	5°	5.9	5°
2.5	.64	4.2	5°	3.3	5°
2.6	.87	8	10°	Not achieved	
2.7	.98	7.8	7.5°	7.0	9°
2.8	1.15	7.8	5°	7.0	8°
2.9	1.15	6.5	7.5°	6.5	7.5°
2.10	1.40	7.7	5°	7.6	7°
2.11	1.40	8.2	7.5°	8.0	7°
2.12	1.66	9.8	0	9.5	2.5°
2.13	1.75	27	5°	23	5°
2.14	2.16	18	0	18	0
2.15	2.47	12.5	0	12.5	0
High Density					
2.16	.29	7.8	-2°	7.8	-4°
2.17	.46	8.2	5°	8	4°
2.18	.57	7.4	0	6.8	5°
2.19	.72	5.8	5°	5.8	8°
2.20	.82	5.6	5° & 10°	5.4	8°
2.21	.94	7.2	5°	7.0	8°
2.22	1.00	No drag results			
2.23	1.15	7.0	5°	Not achieved	
2.24	1.50	10.6	0°	9.2	2°

TABLE 2-II. TEST CONDITIONS FOR ZERO TORQUE AND 1G LIFT-COEFFICIENT

Figure Number	Run Number	Pressure (in. Hg.)	μ	θ_o (deg)	α_{TPP} (deg)
2.6	35/36	12	.87	2	13
2.10	43	12	1.40	3.5	11
2.12	47	12	1.66	2	8.5
2.13	44	12	1.75	1	6
2.14	48	12	2.16	0.5	2
2.16	50	30	.29	1.5	8
2.17	51	30	.46	2.9	7
2.18	52	30	.57	4.5	6
2.19	57	30	.72	4	7.5
2.20	56	30	.82	5	9

TABLE 5-I COMPARISON OF ROTOR CHARACTERISTICS
PHASE I STUDY VS. PHASE II MODEL

Characteristic	Phase I Study	Phase II Model
Radius - inches	338	48.36
Chord - inches	35.2	5.00
Root cutout - non dim.	.150	.232
Root airfoil thickness ratio - non dim.	.150	.180
Tip airfoil thickness ratio - non dim.	.060	.060
Twist angle - deg.	0	0
Number of blades	4	4
Solidity - non dim.	.133	.133
Normal tip speed - ft/sec	700	700
Normal disk loading - lb/sq ft	8	8
Flap hinge offset* - non dim.	0	.065
Flapping inertia per blade lb/in^2	16.5×10^6	2972
Flapping moment lb/in	75,000	132
Flapping root spring, non dim.	2.46×10^6	0
Lock number per blade	6.0	2.3
Delta - 3 - degrees	0	26.5
Flap frequency at normal tip speed - non dim.	1.05	1.07
Aerodynamic data assumptions:		
Number of spanwise stations	2	5
Thickness - chord ratio at stations	12%	16.8%
	7%	14.4%
		12.0%
		9.6%
		7.2%
Maximum lift coefficient in radial flow option	3.5	2.5
Atmospheric conditions:		
Altitude - feet	3000	Sea level
Temperature - °F	91.5	59
Density - $slugs/ft^3$	.001998	.002378
Speed of sound - ft/sec	1150	1117

* The Phase I rotor was hingeless simulated by a flapping spring at a zero offset hinge. The Phase II rotor is fully articulated.

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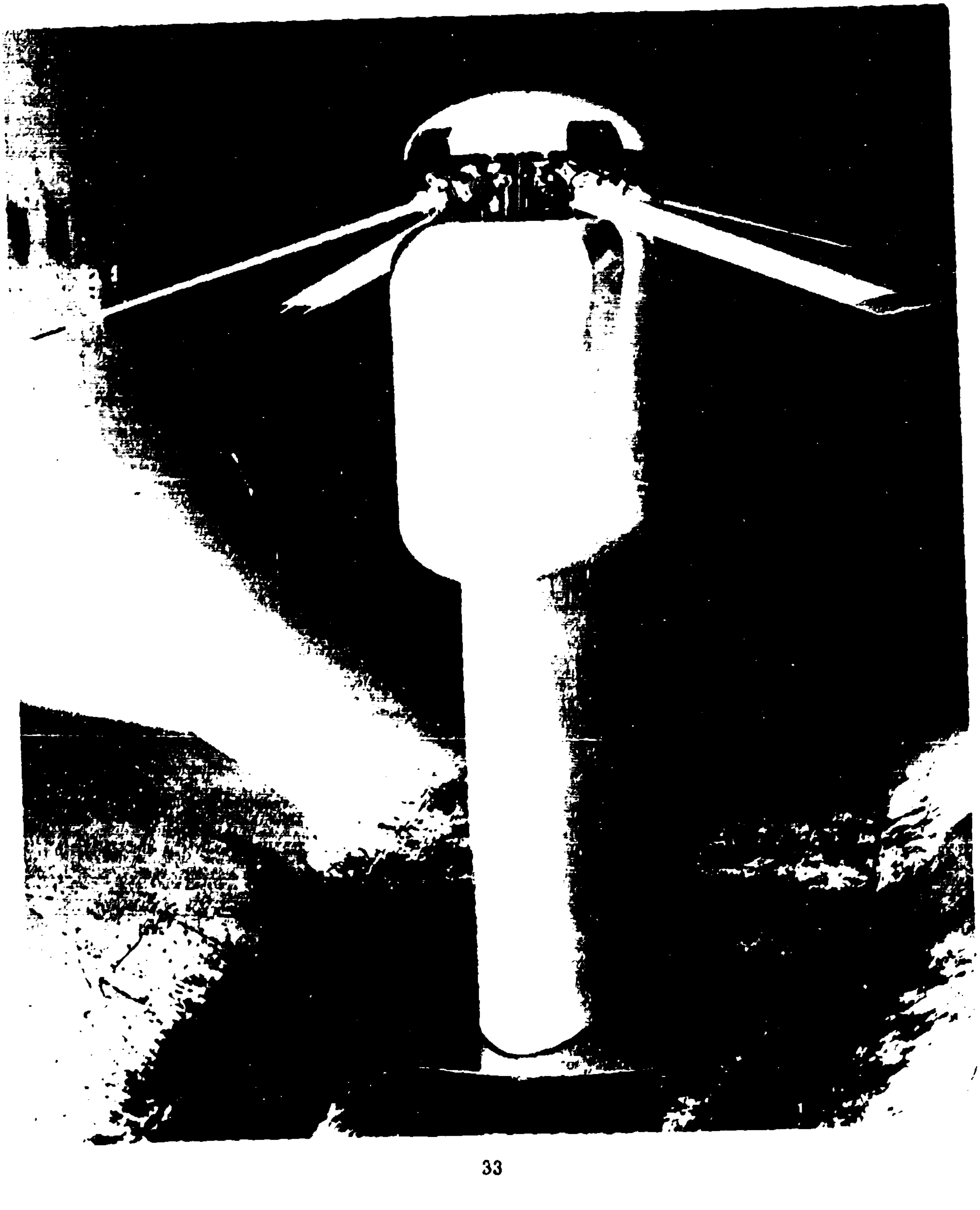
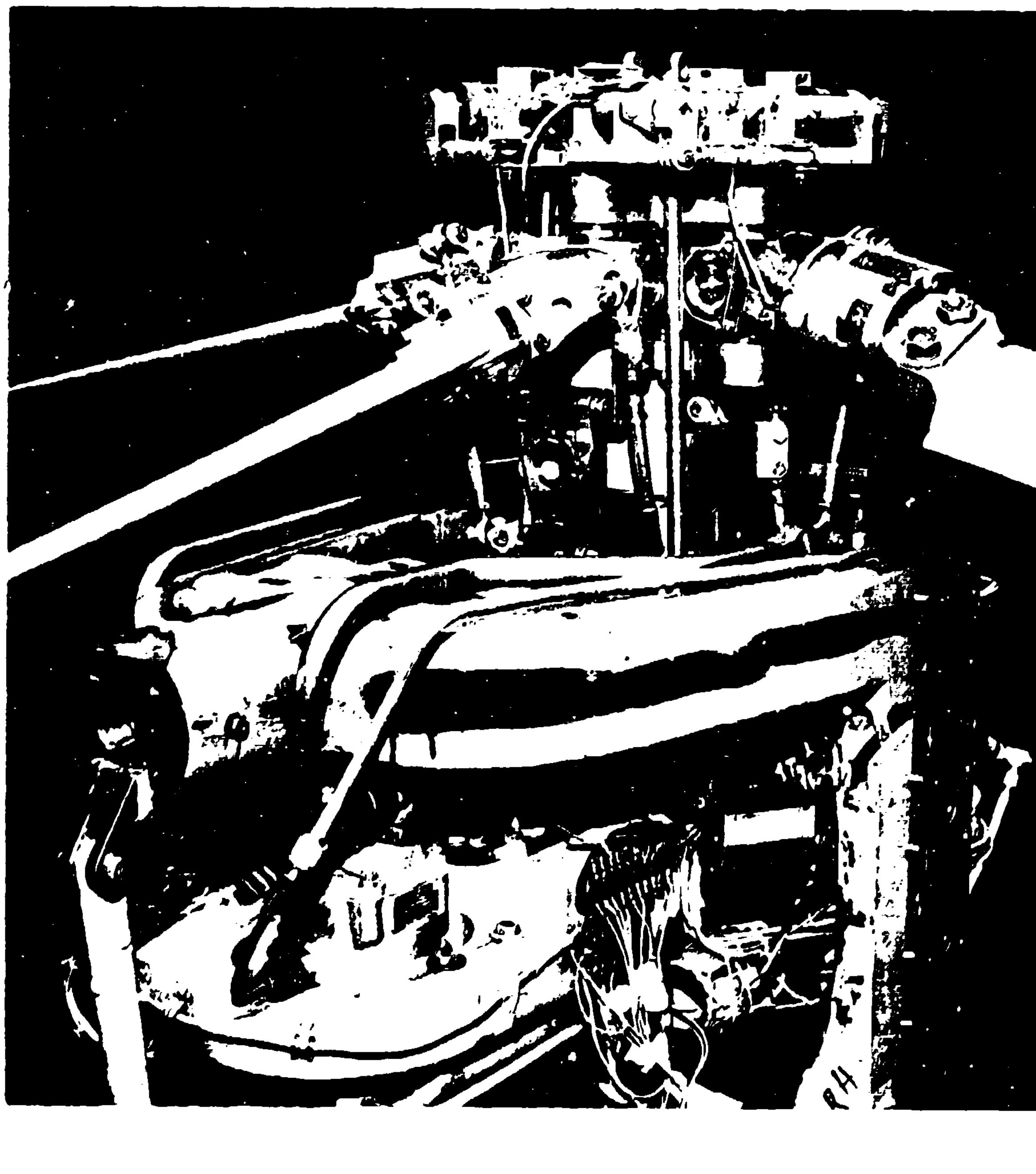
INSTALLATION OF REVERSE VELOCITY ROTOR TEST RIG
IN NASA AMES 12 FT PRESSURE TUNNEL



THREE-QUARTER REAR VIEW OF REVERSE VELOCITY ROTOR TEST RIG
(Fairing Removed)



REVERSE VELOCITY ROTOR TEST RIG - GEOMETRIC LAYOUT

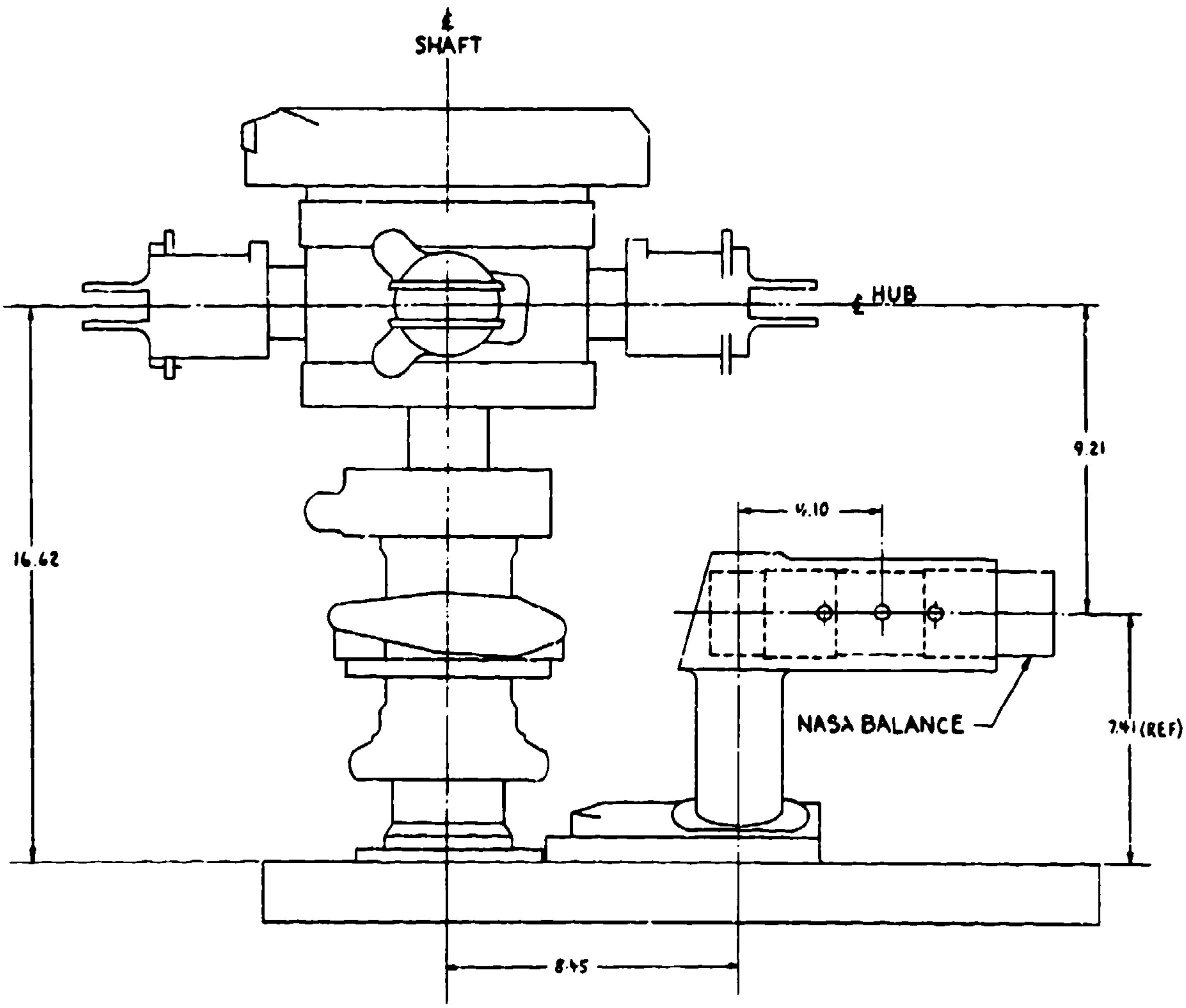
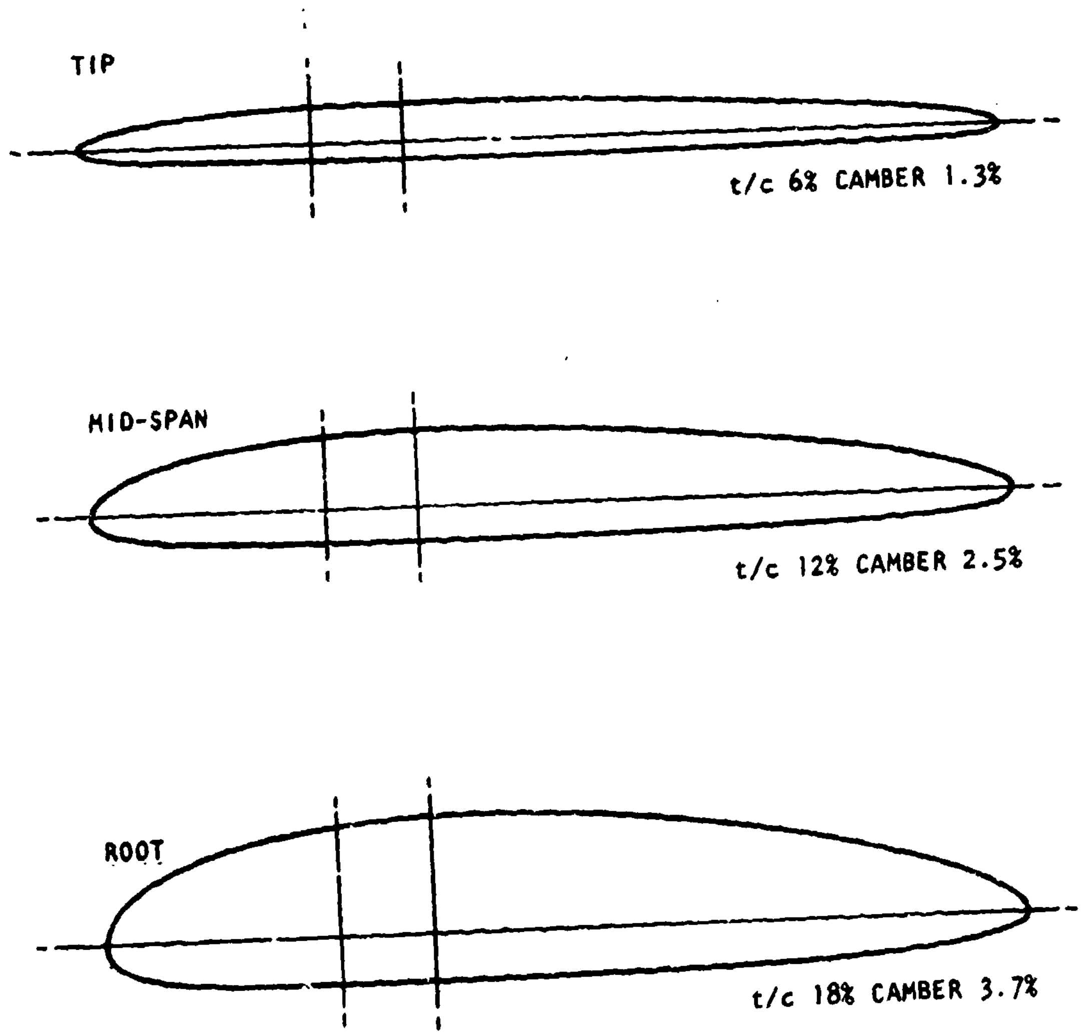


Figure 1.4

MODEL ROTOR AIRFOIL SECTIONS



SECTION PROPERTIES - 1/7 SCALE MODEL RVR ROTOR BLADE

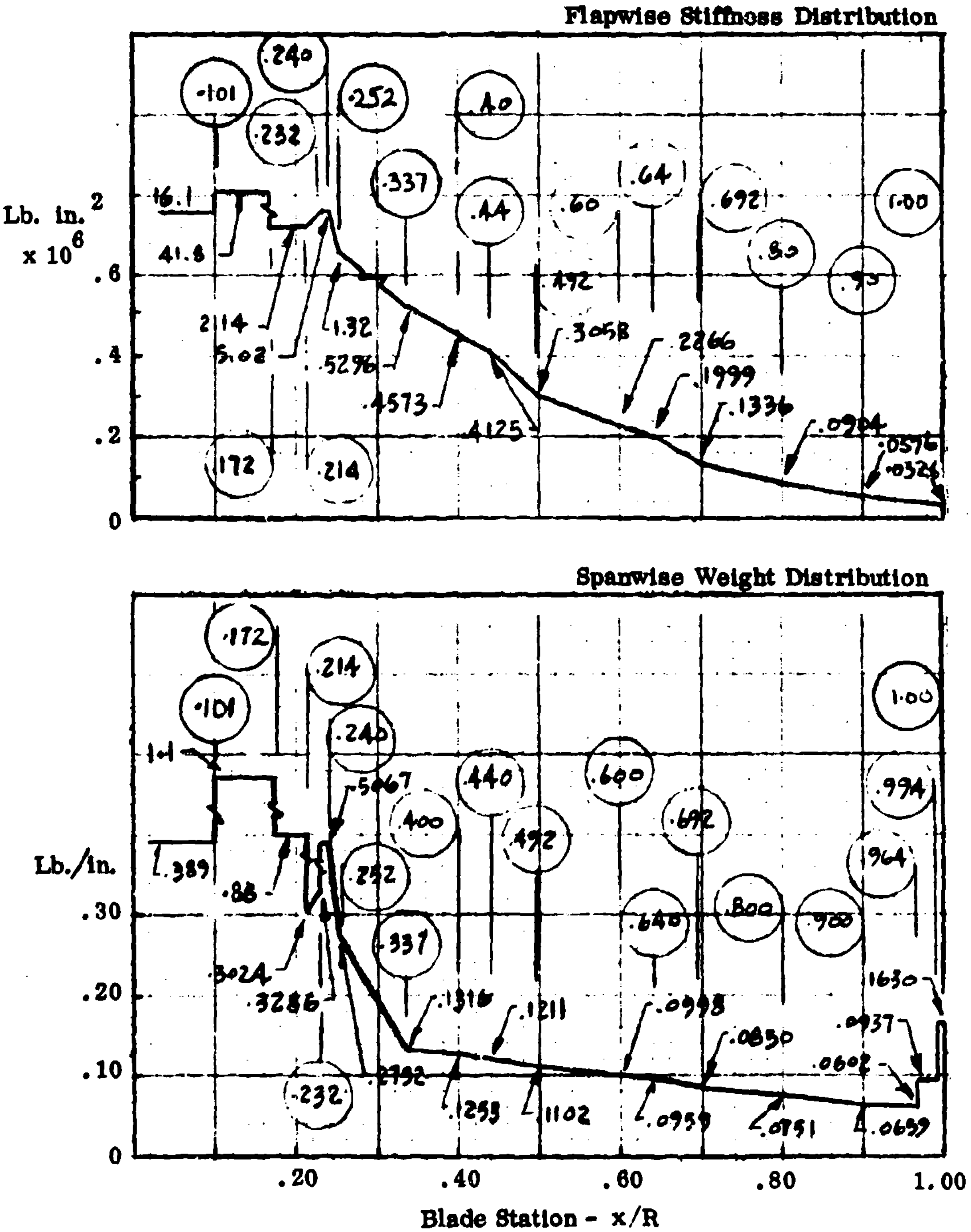


Figure 1.6

SECTION PROPERTIES - SCALE MODEL
RVR ROTOR BLADE (CONTINUED)

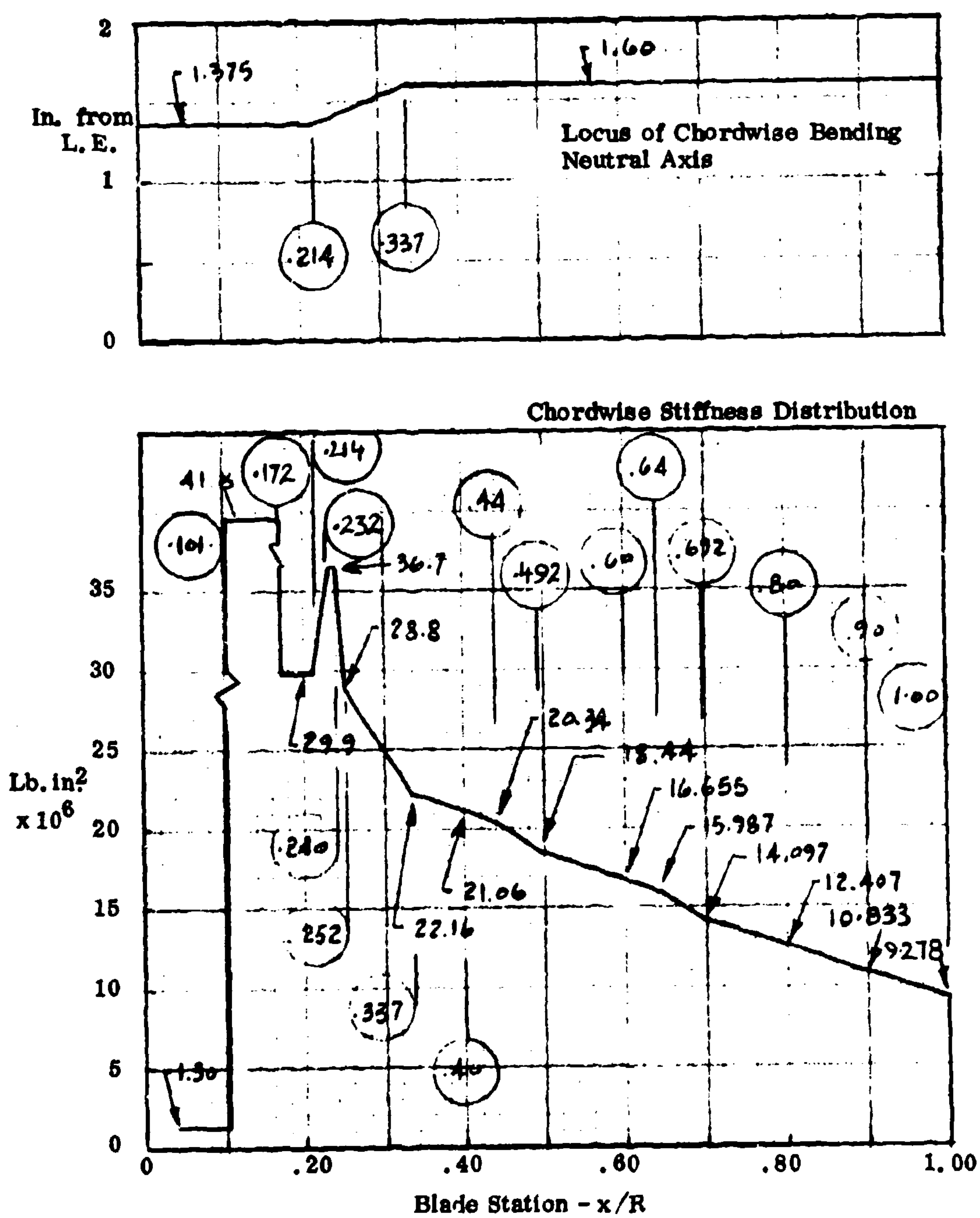
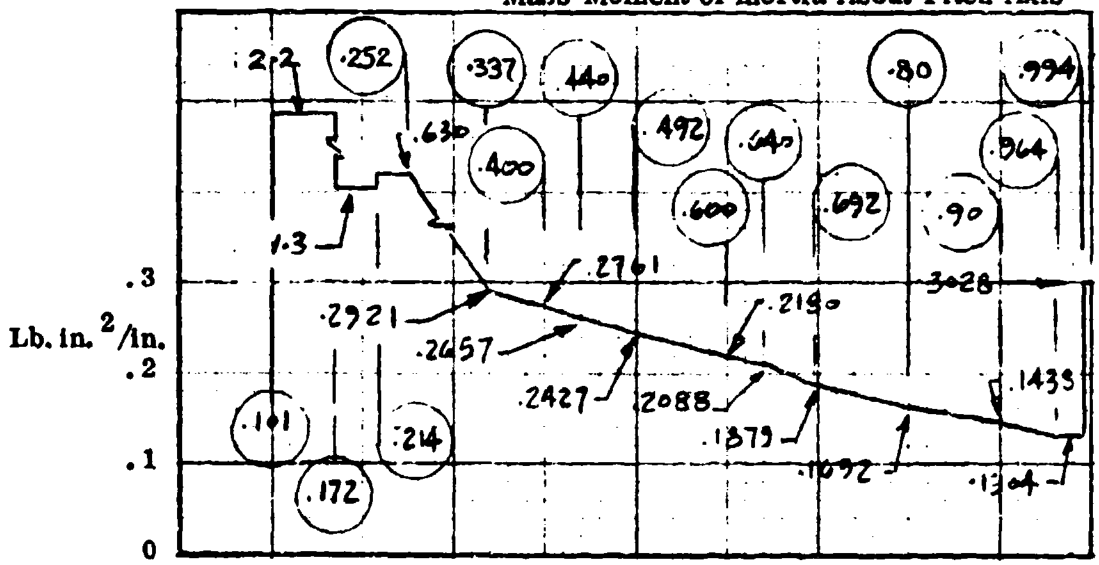


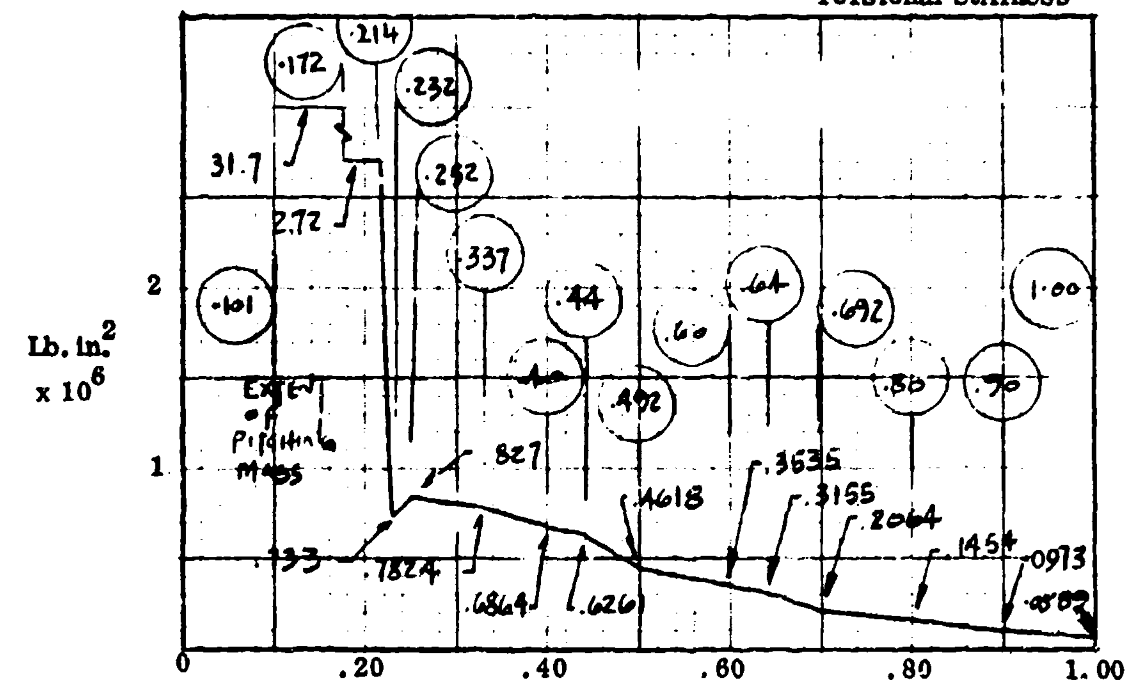
Figure 1.7

SECTION PROPERTIES - SCALE MODEL RVR ROTOR BLADE (CONCLUDED)

Mass Moment of Inertia About Pitch Axis



Torsional Stiffness

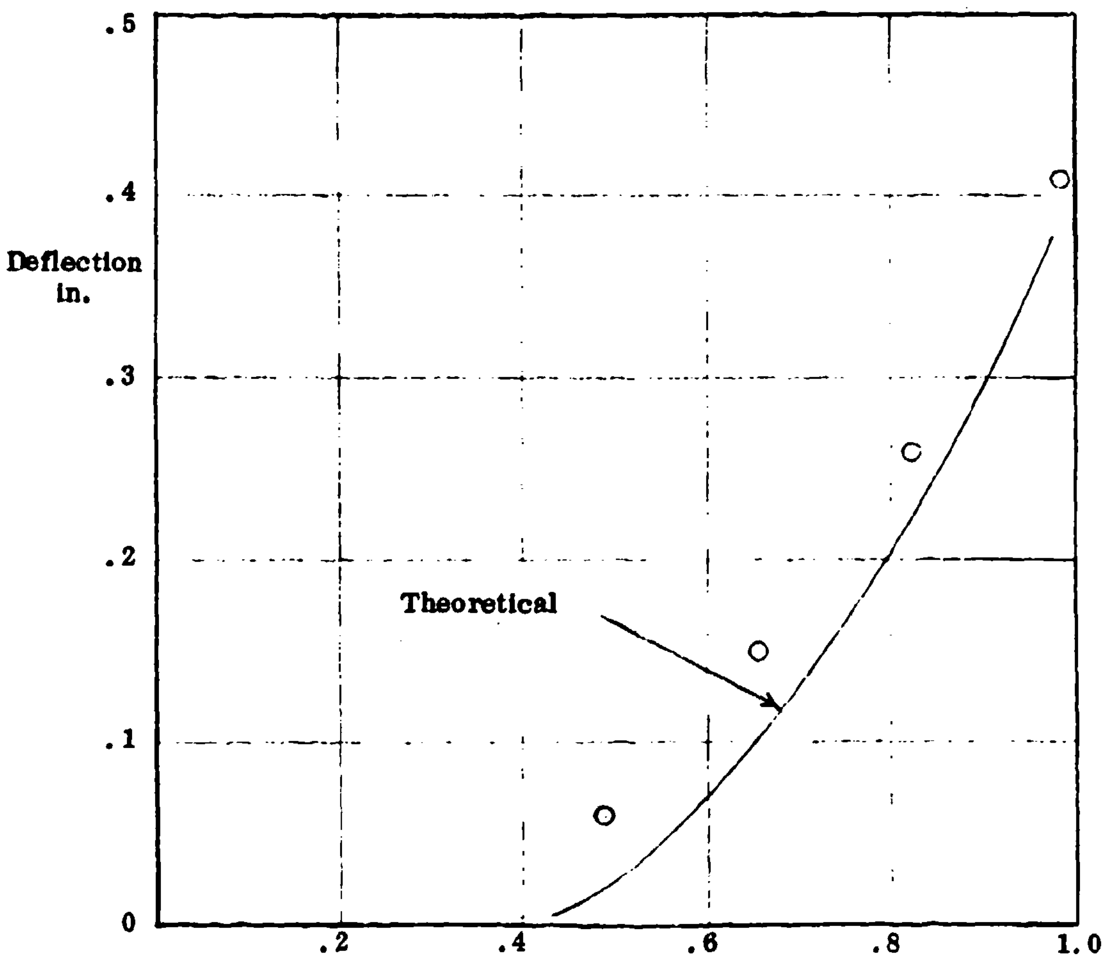


Blade Station - x/R

Figure 1.8

PREDICTED AND MEASURED FLAPWISE STIFFNESS
1/7 SCALE MODEL RVR ROTOR BLADE
Deflection with 10 lbs load applied at .95 radius

O = Measured, qualification blade



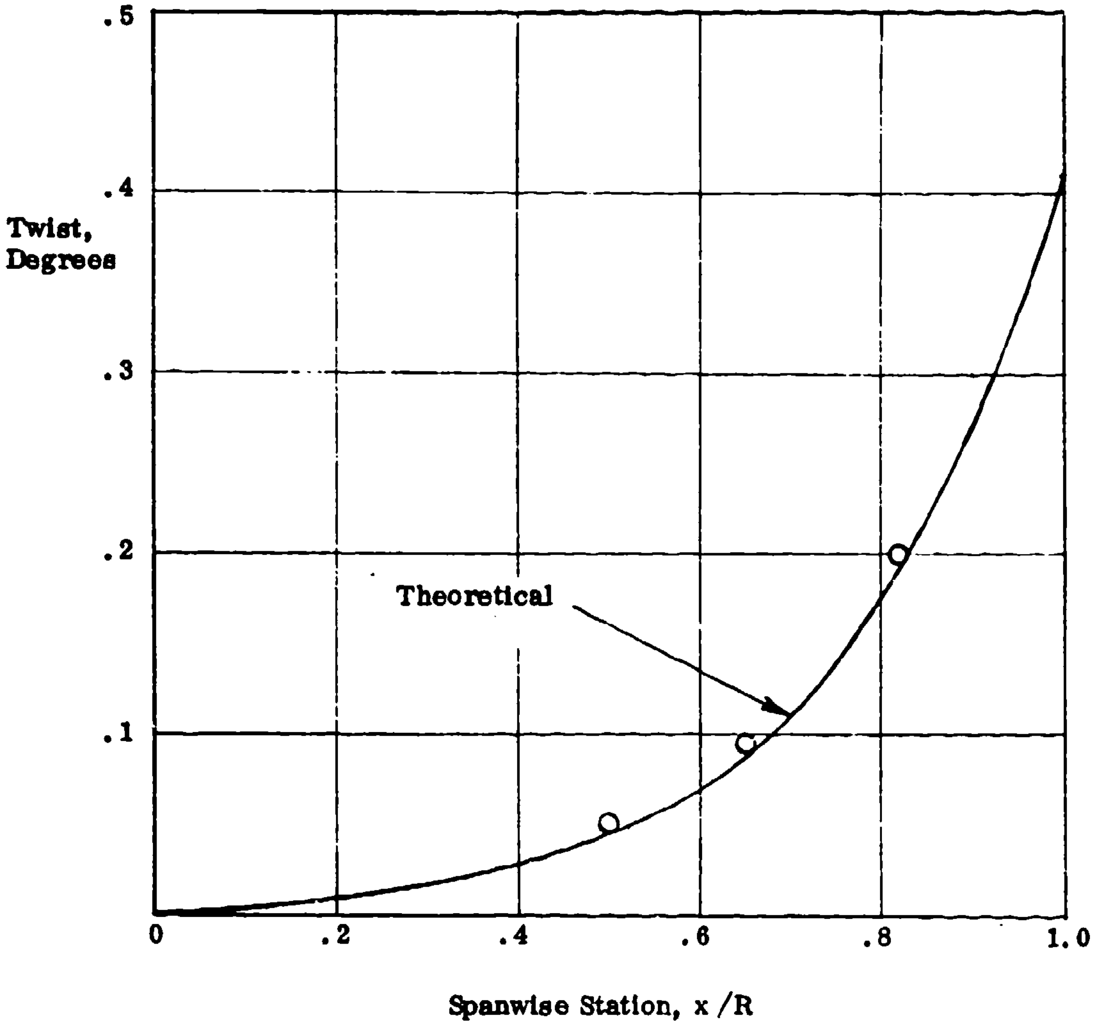
Spanwise Station, x/R

Figure 1.9

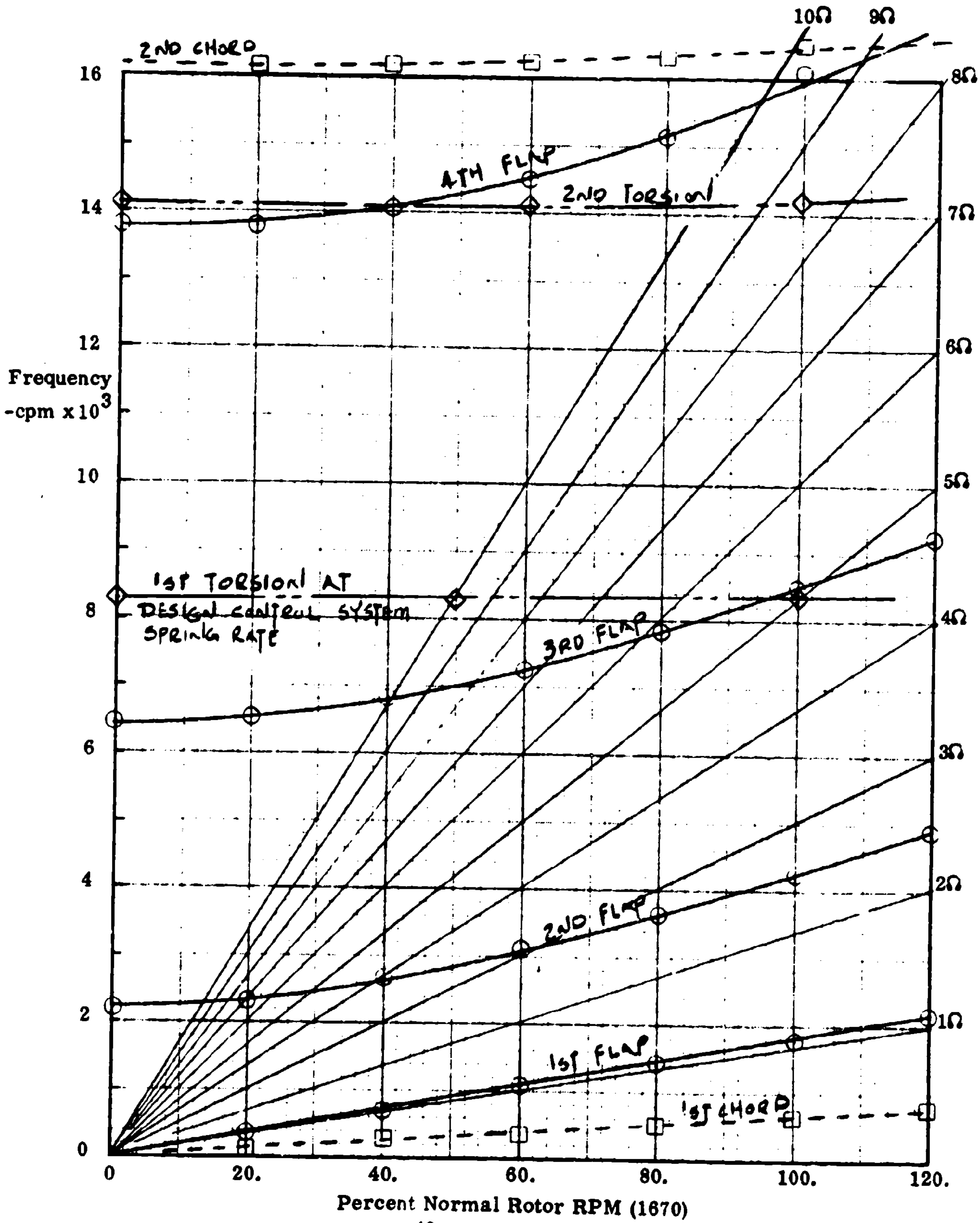
PREDICTED AND MEASURED TORSIONAL STIFFNESS
1/7 SCALE MODEL RVR ROTOR BLADE

Deflection with 100 in. lb. torque applied at .93 radius

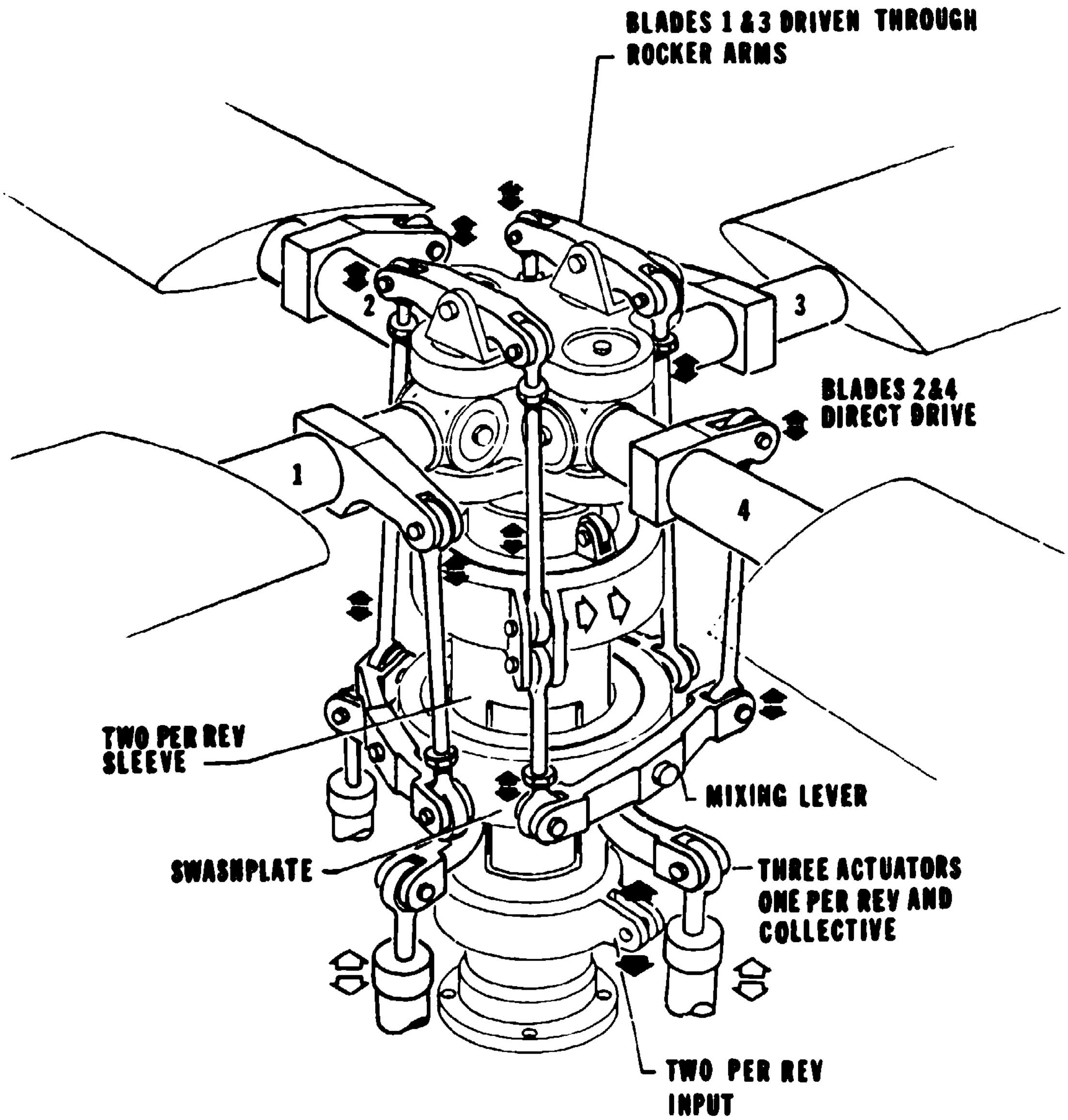
O = Measured, qualification blade



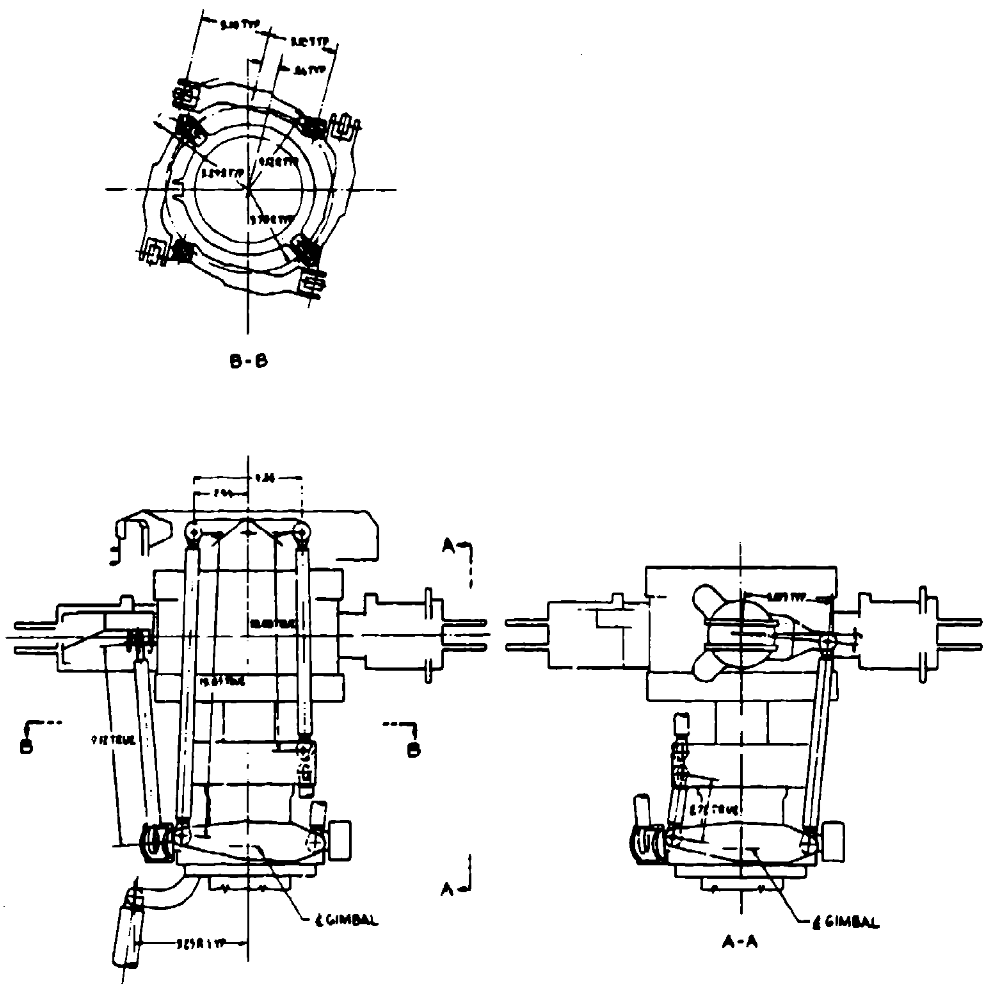
NATURAL FREQUENCY SPECTRUM - 1/7 SCALE MODEL
RVR ROTOR BLADE



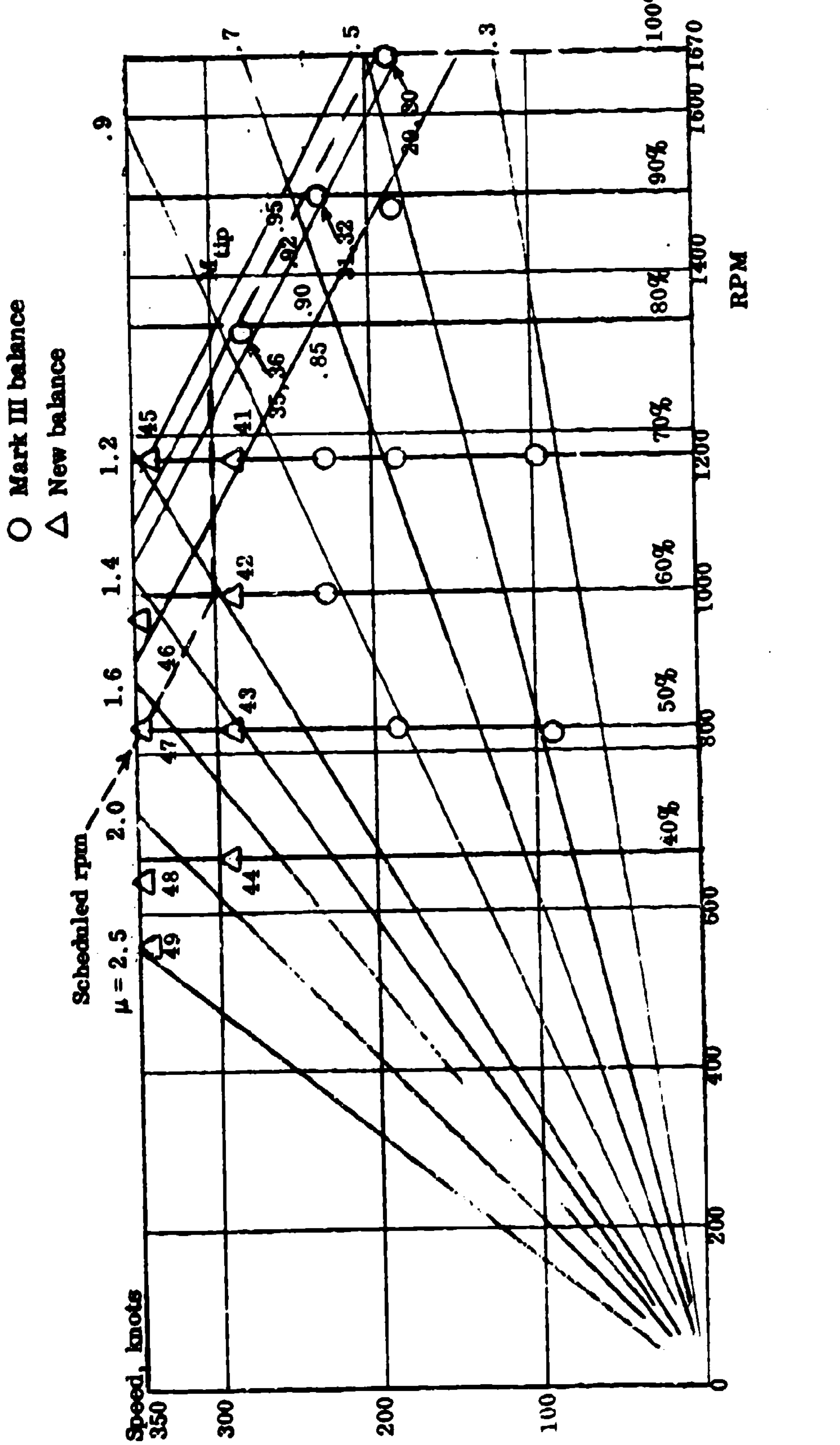
CONTROL SYSTEM
1/7 SCALE R.V.R MODEL



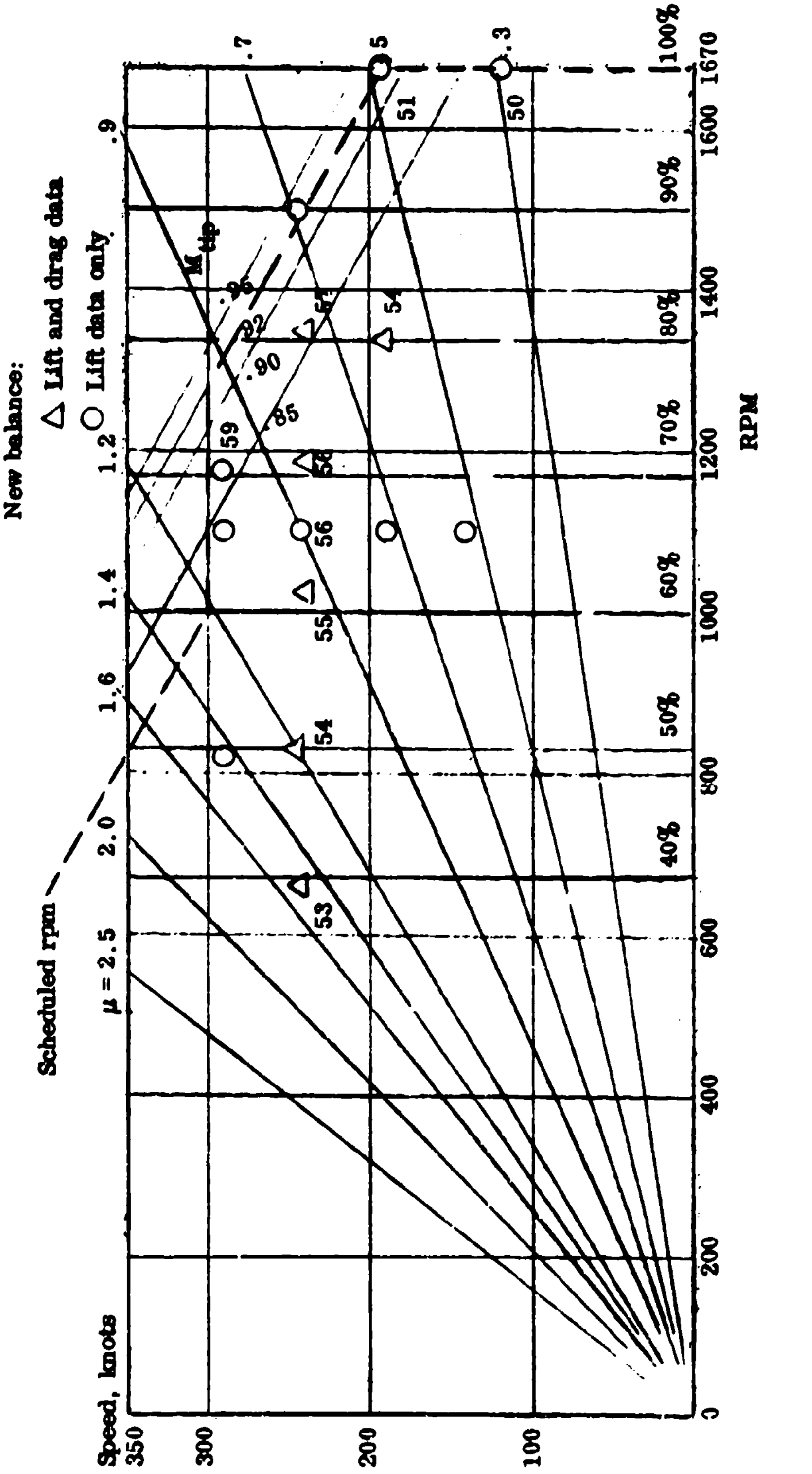
REVERSE VELOCITY ROTOR TEST RIG - CONTROL SYSTEM DIMENSIONS



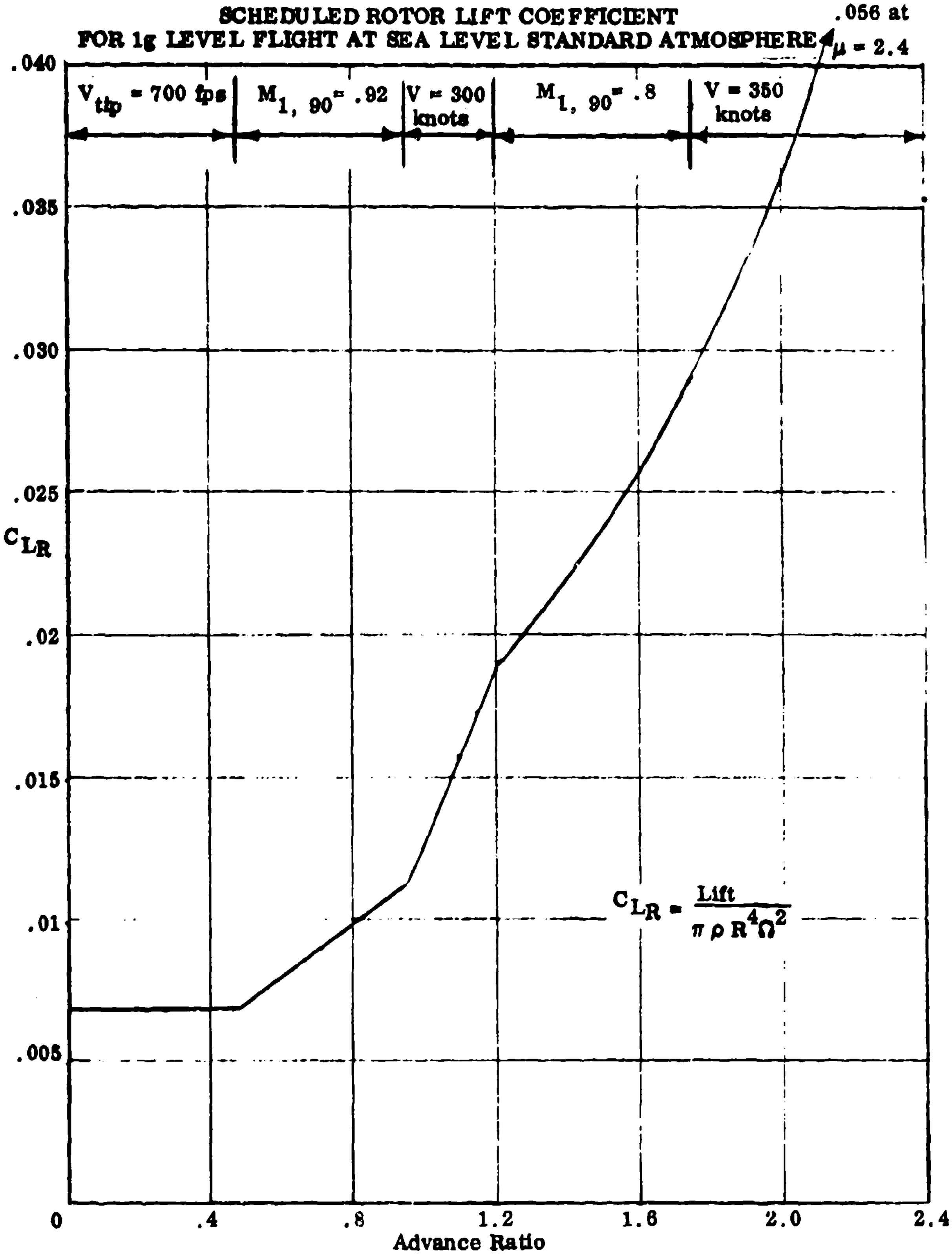
OPERATING ENVELOPE AND TEST CONDITIONS - REDUCED PRESSURE



OPERATING ENVELOPE AND TEST CONDITIONS - ATMOSPHERIC PRESSURE

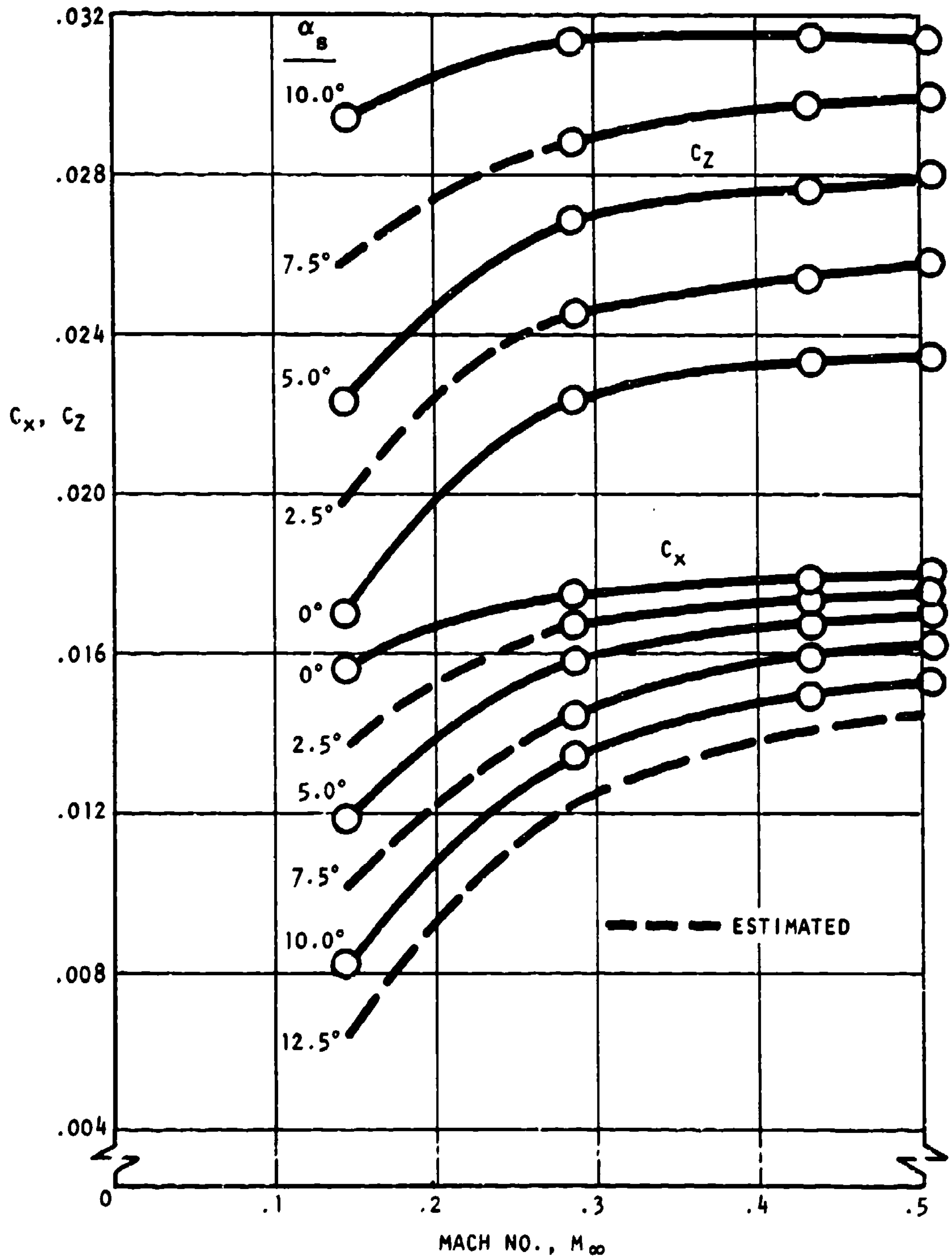


SCHEDULED ROTOR LIFT COEFFICIENT
FOR 1g LEVEL FLIGHT AT SEA LEVEL STANDARD ATMOSPHERE



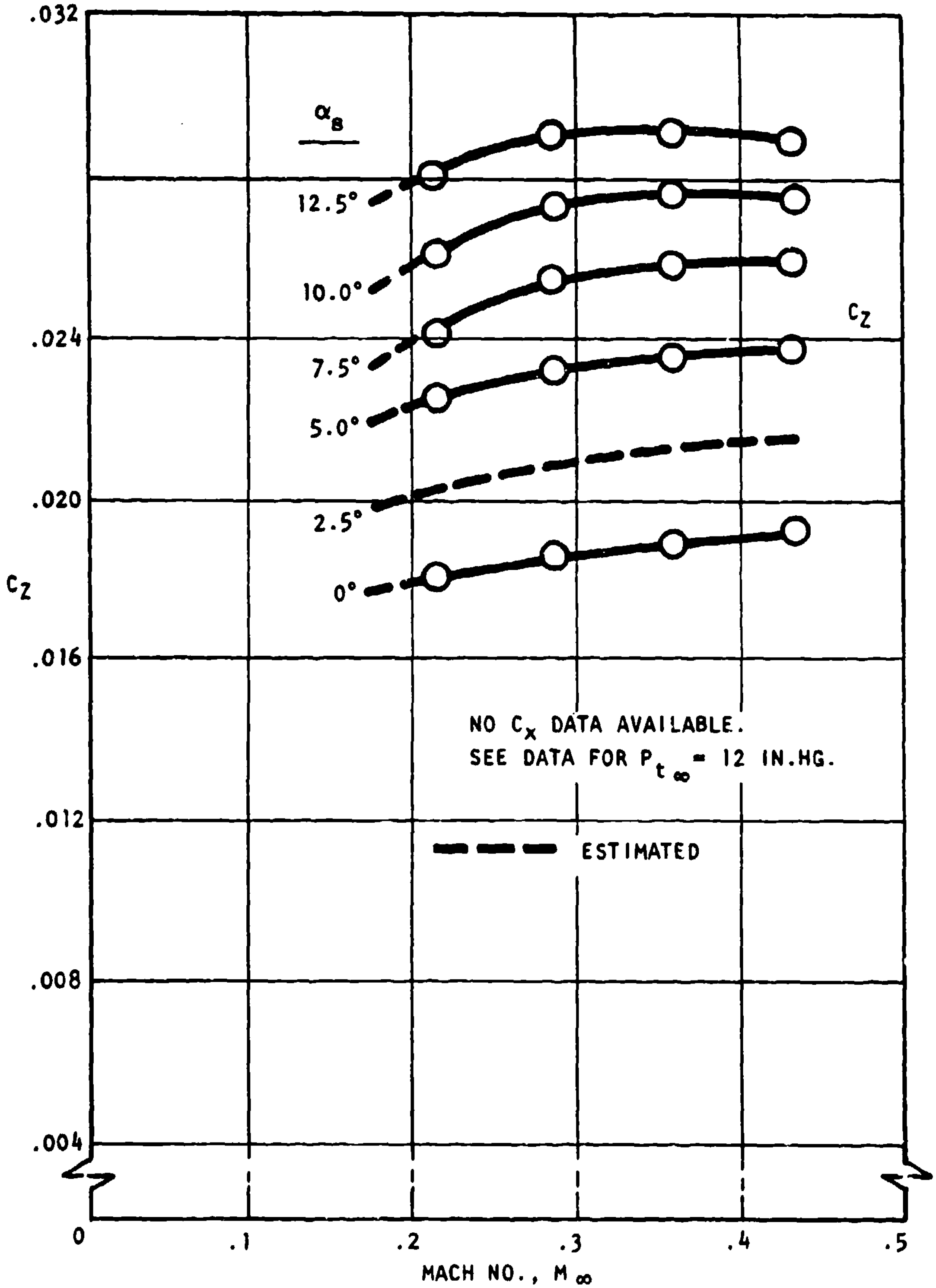
HUB TARE CORRECTIONS TO NORMAL AND AXIAL FORCE COEFFICIENTS

Tunnel Pressure - 12 in. Mercury

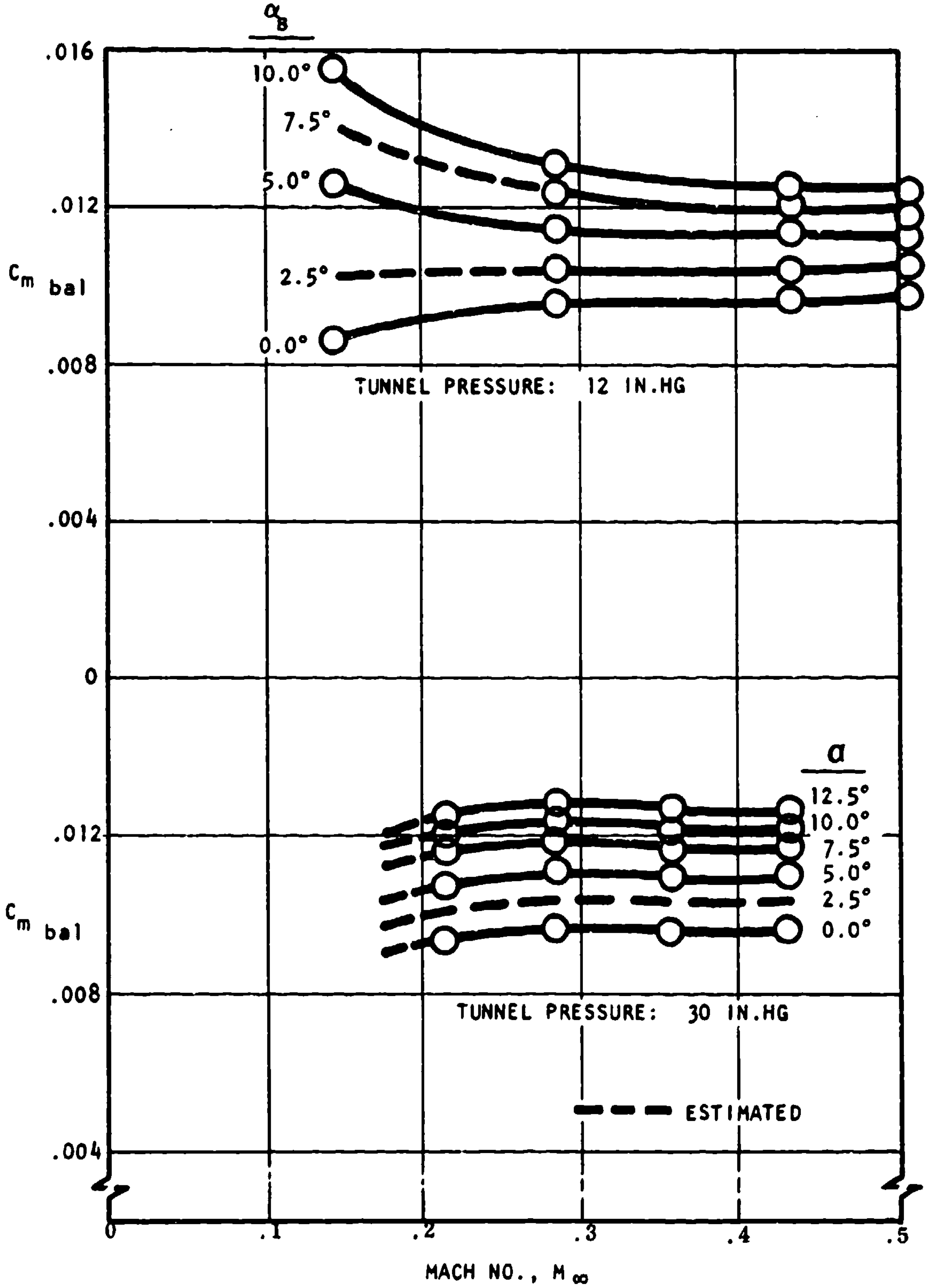


HUB TARE CORRECTIONS TO NORMAL FORCE COEFFICIENT

Tunnel Pressure - 30 in. Mercury



HUB TARE CORRECTIONS TO BALANCE PITCHING MOMENT COEFFICIENT



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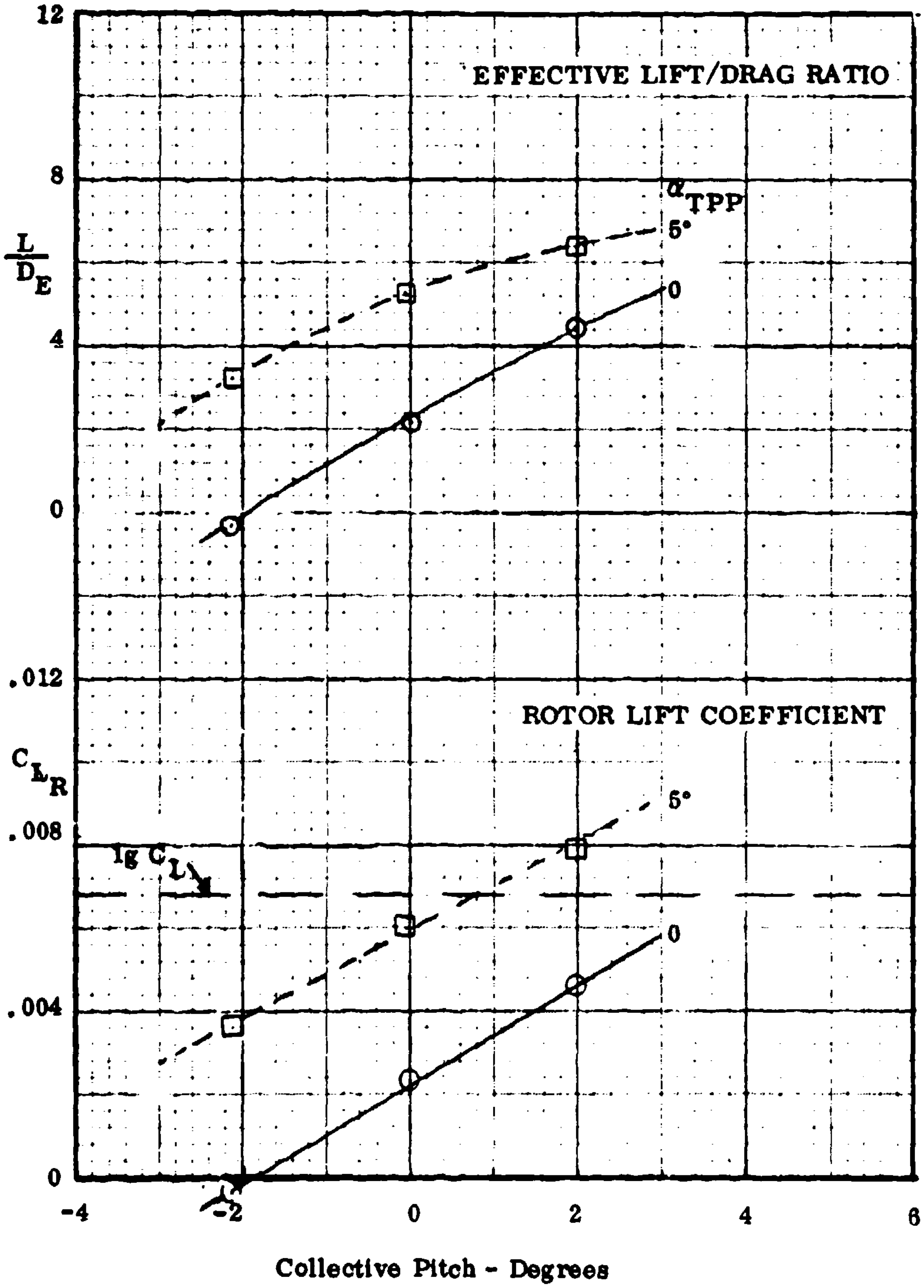
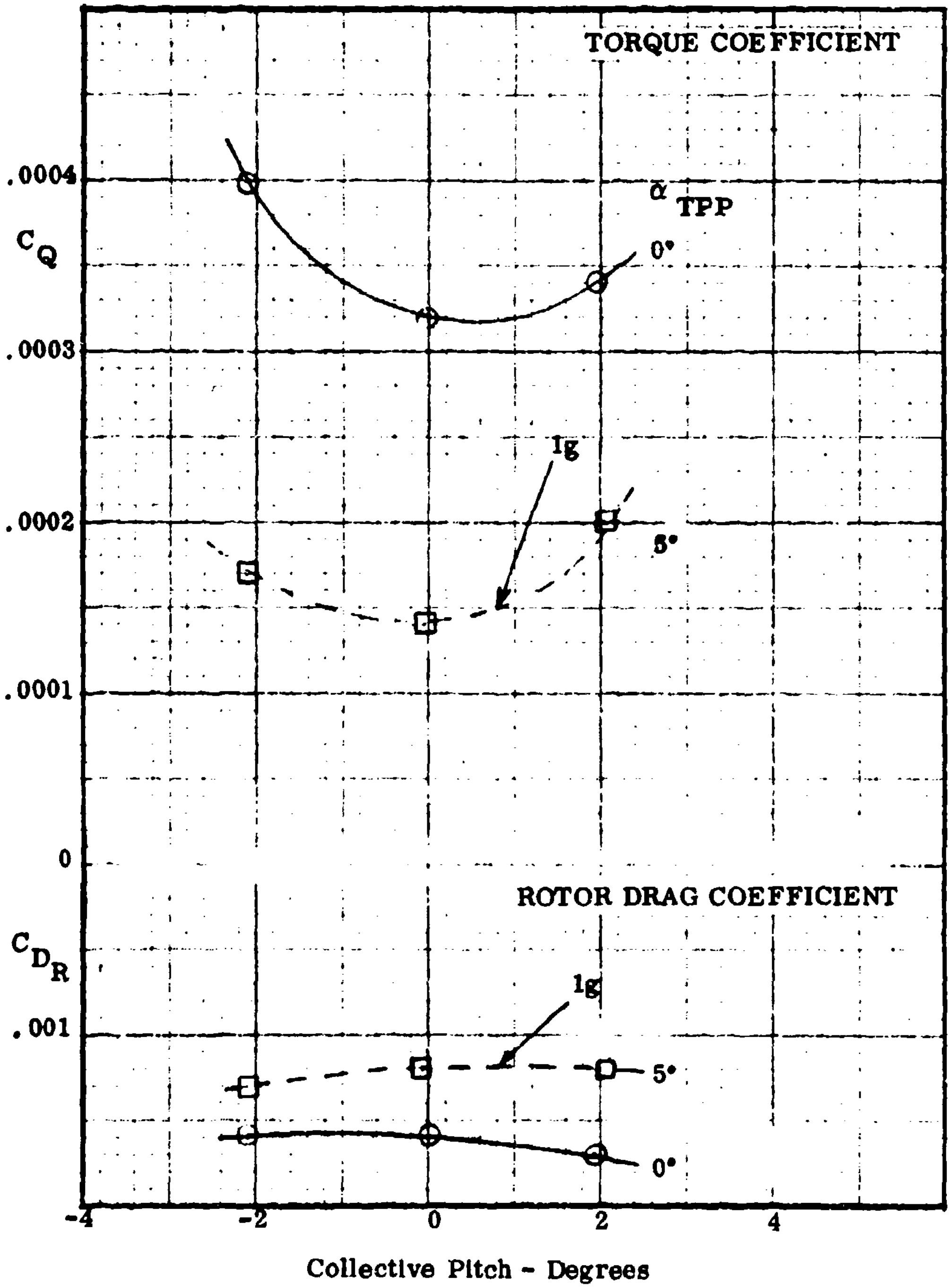
MEASURED ROTOR PERFORMANCE

$\mu = .46$, 1670 r.p.m., 187 knots, $M_{1,90} = .89$, $\rho = .00090$, runs 29&30



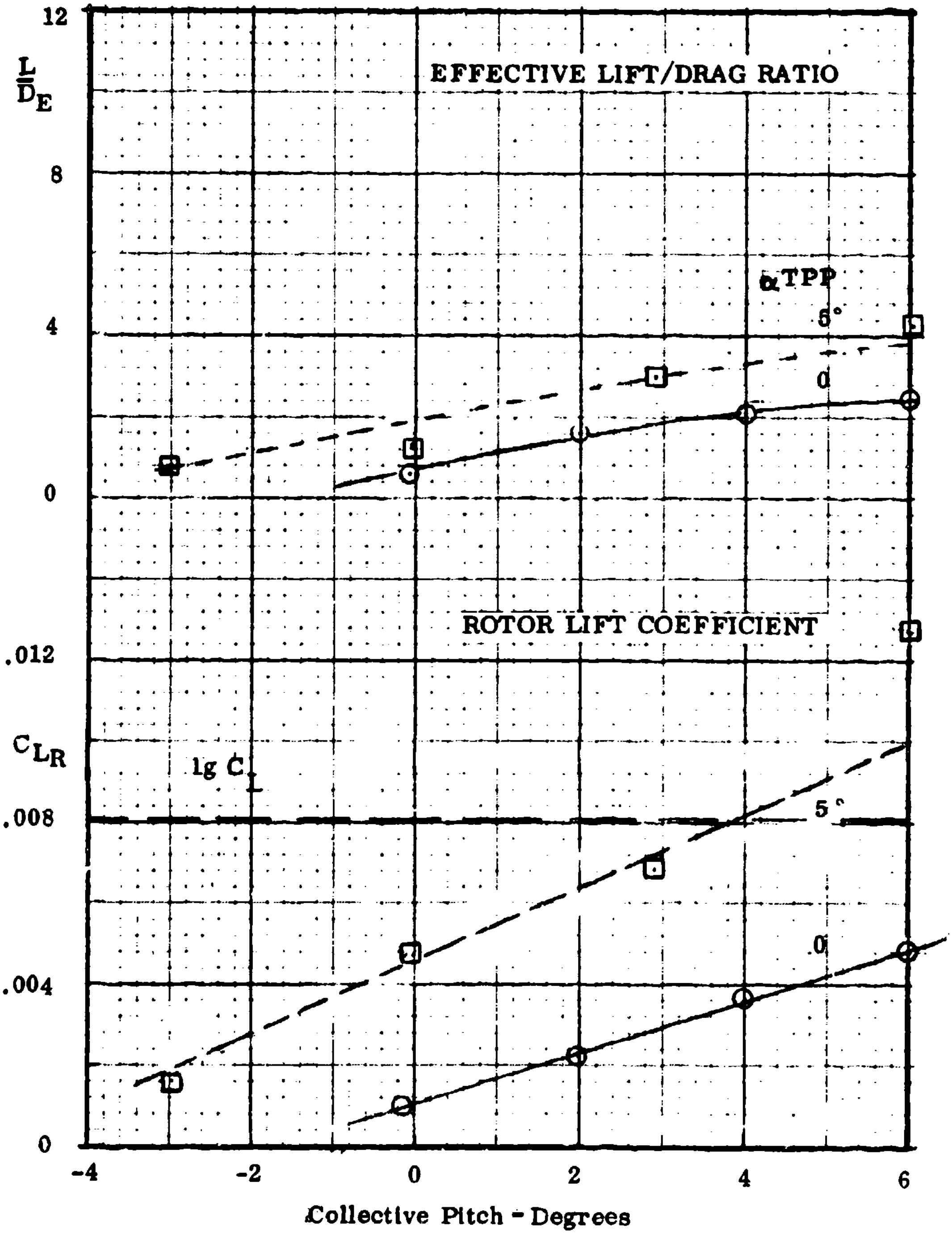
MEASURED ROTOR PERFORMANCE

$\mu = .46$, 1670 r.p.m., 187 knots, $M_{1,90} = .89$, $\rho = .00090$, runs 29&30



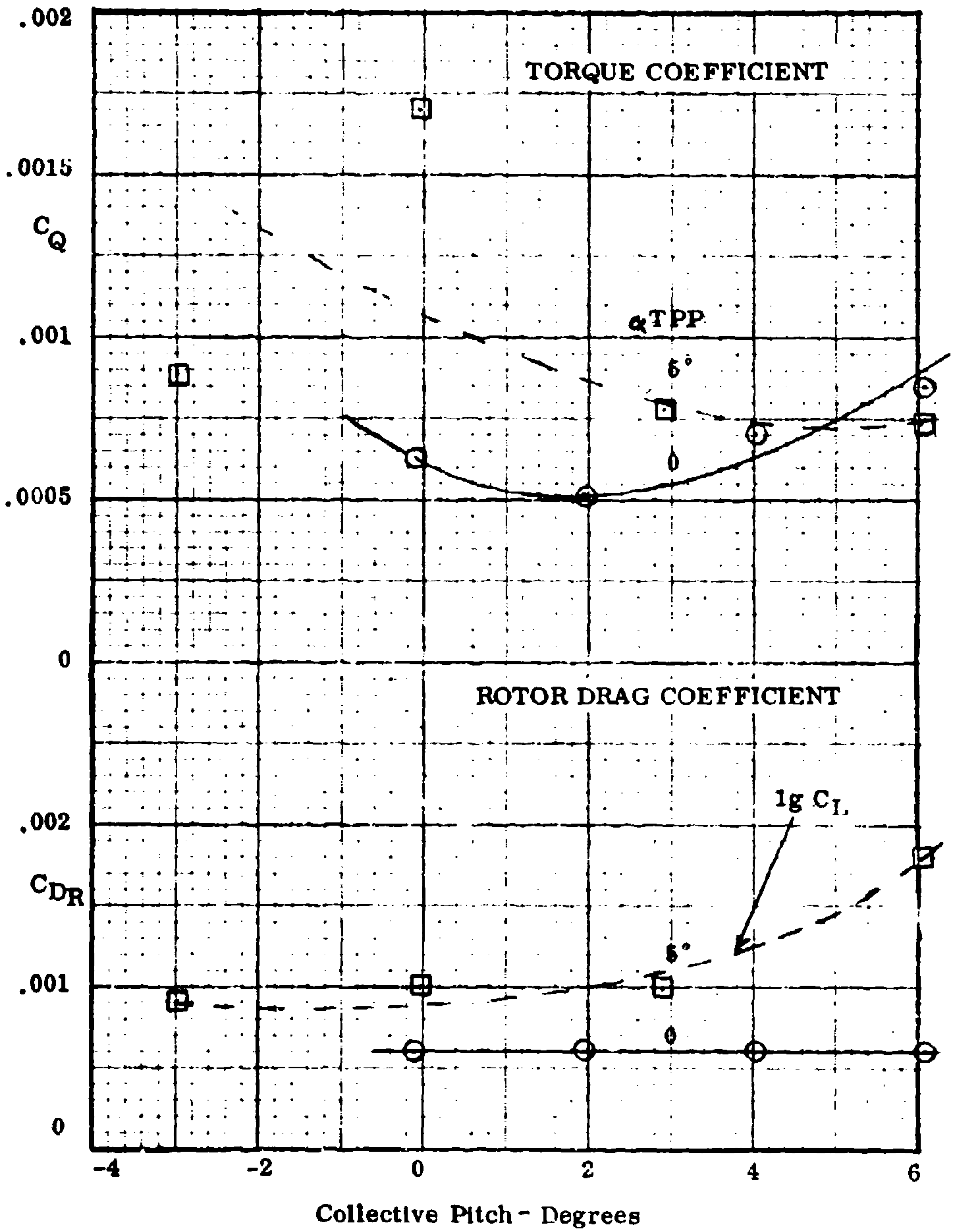
MEASURED ROTOR PERFORMANCE

μ = .64, 1500 r.p.m., 230 knots, $M_{1,90}$ = .90, ρ = .00089, runs 31 & 32



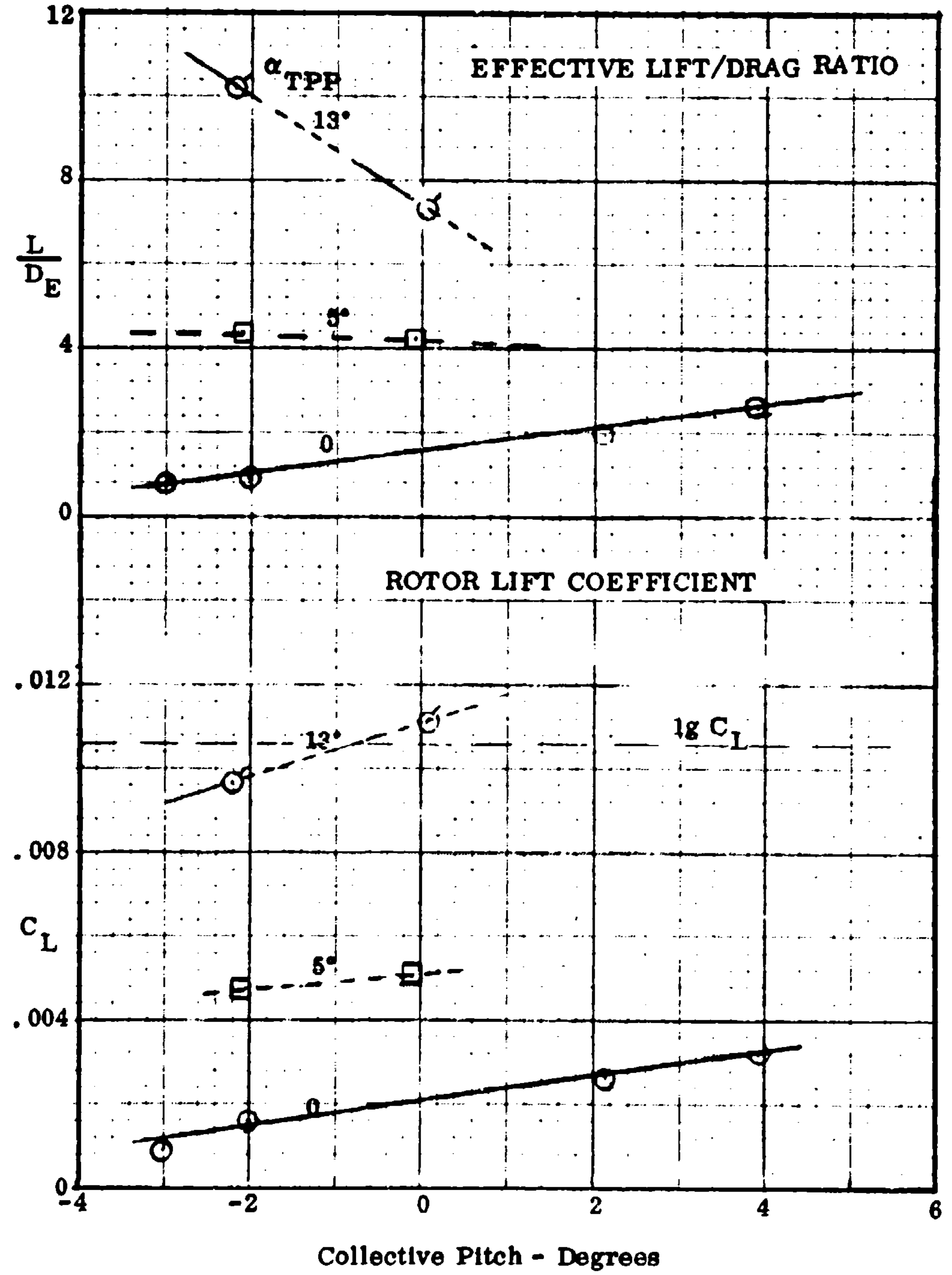
MEASURED ROTOR PERFORMANCE

μ =.64, 1500 r.p.m., 230 knots, $M_{1,90}$ = .90, ρ = .00089, runs 31 & 32



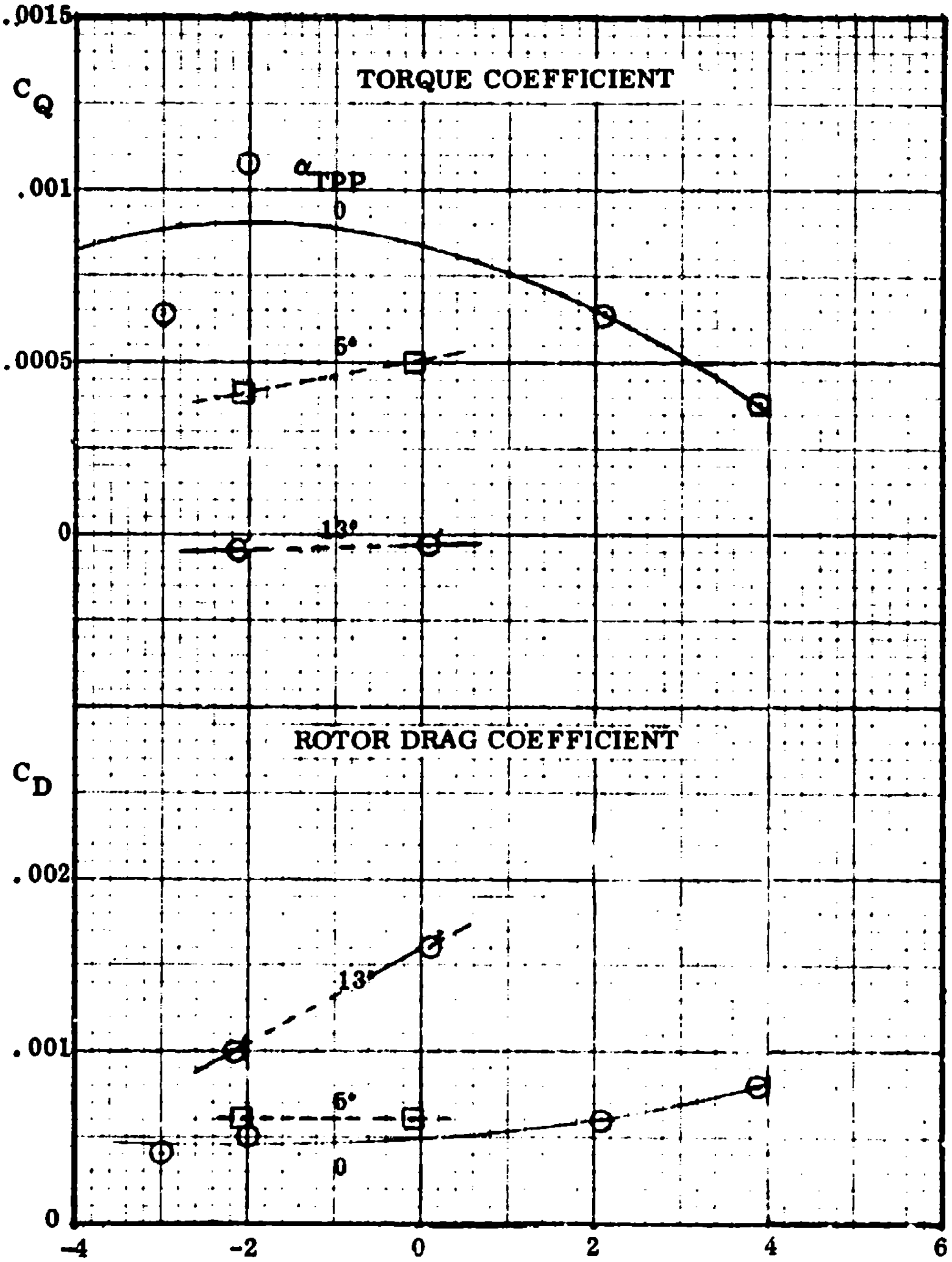
MEASURED ROTOR PERFORMANCE

μ = .87, 1330 r.p.m., 281 knots, $M_{1,90}$ = .92, ρ = .00086, runs 35&36



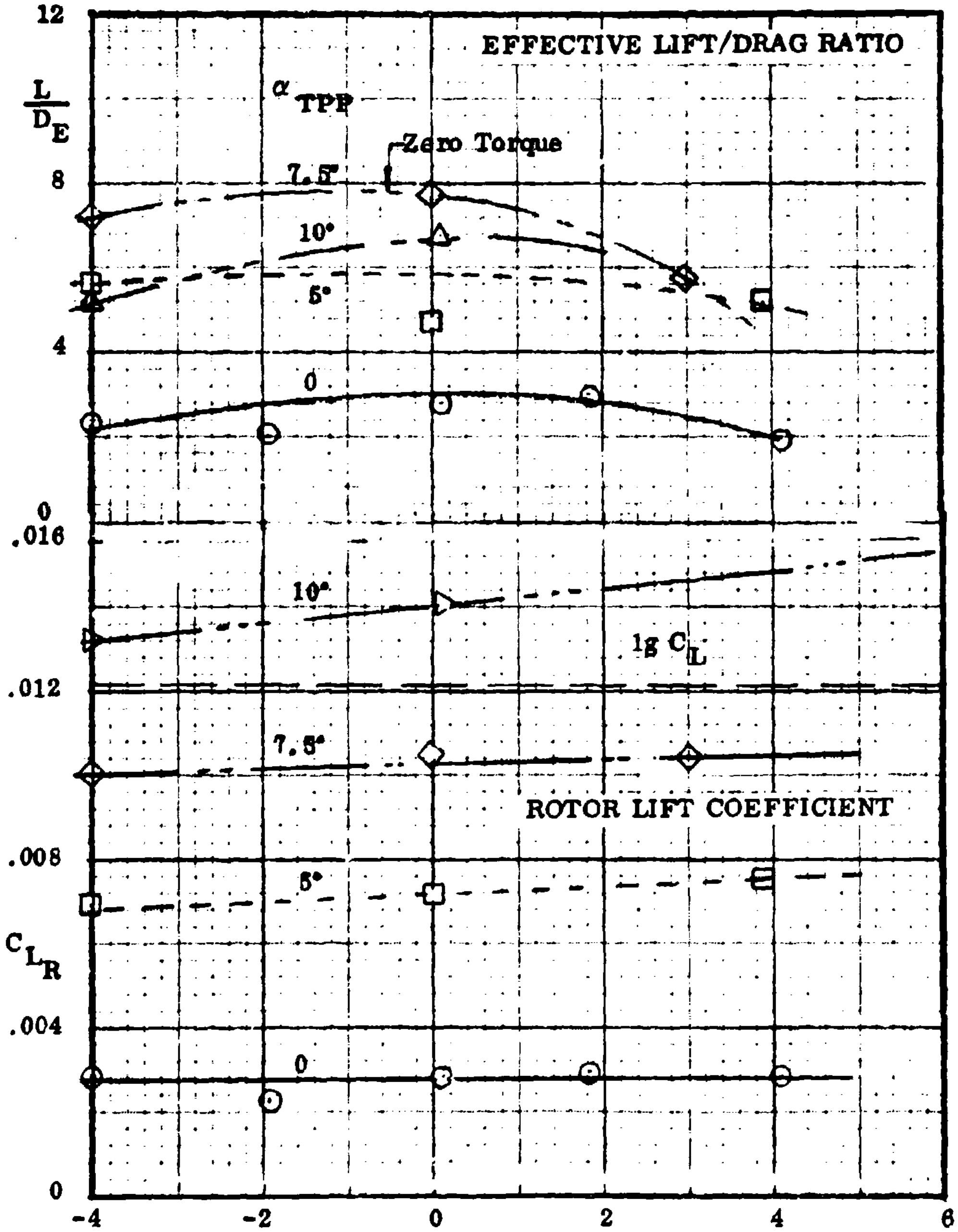
MEASURED ROTOR PERFORMANCE

$\mu = .87$, 1330 r.p.m., 281 knots, $M_{1,90} = .92$, $\rho = .00086$, runs 35&36



MEASURED ROTOR PERFORMANCE

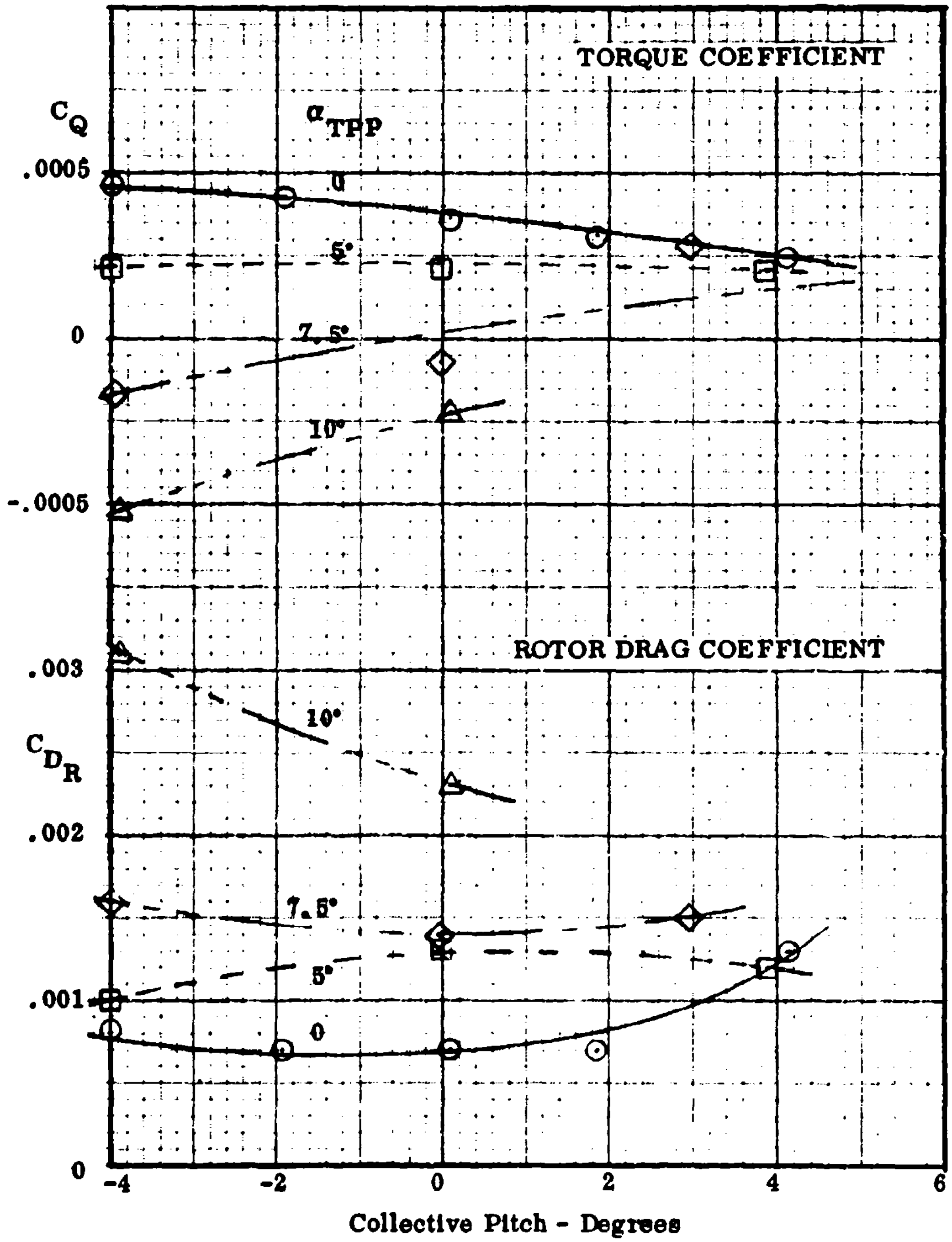
$\mu = .98$, 1170 r.p.m., 288 knots, $M_{1,90} = .84$, $\rho = .00087$, run 41



Collective Pitch - Degrees

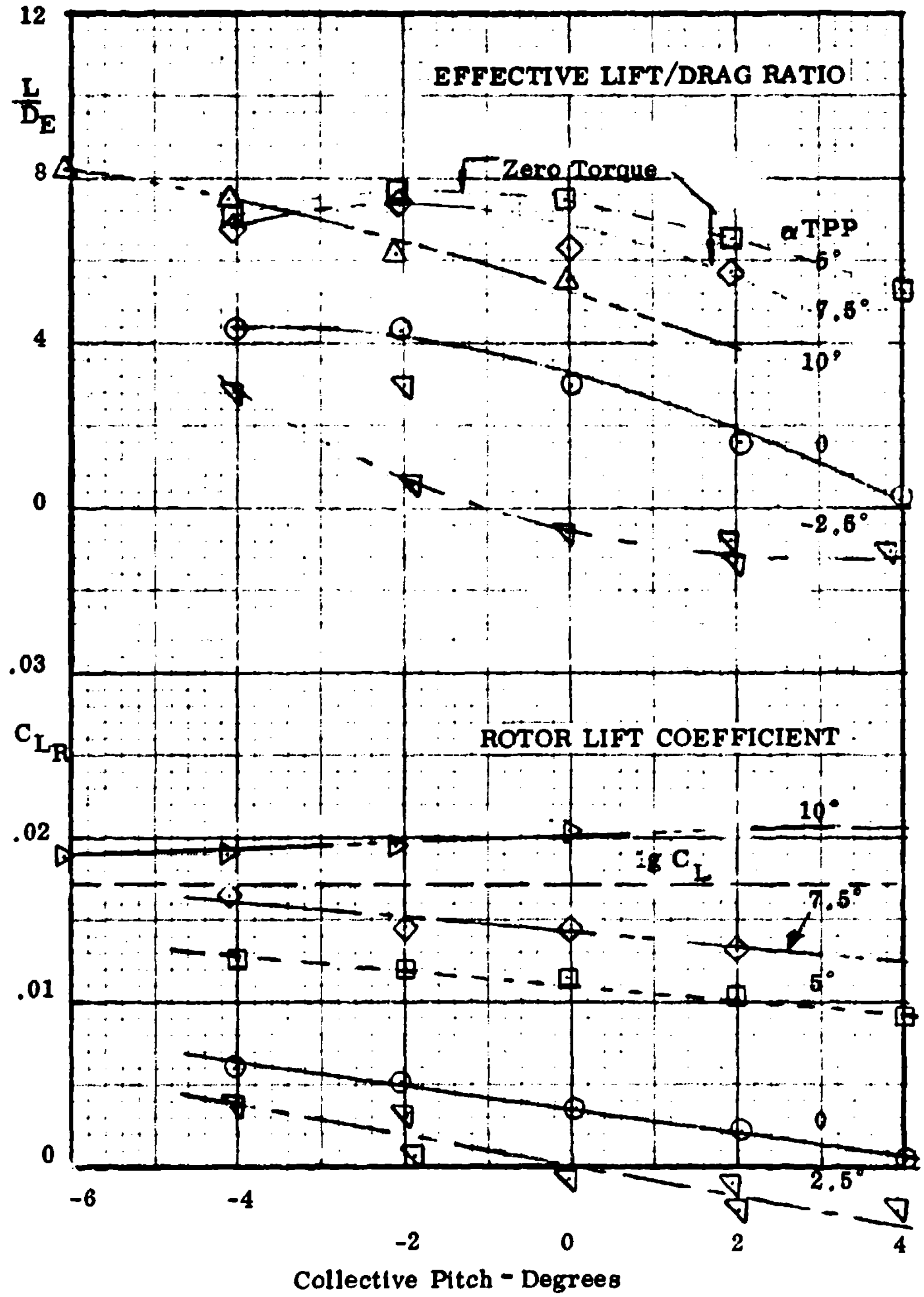
MEASURED ROTOR PERFORMANCE

$\mu = .98$, 1170 r.p.m., 288 knots, $M_{1,90} = .84$, $\rho = .00087$, run 41



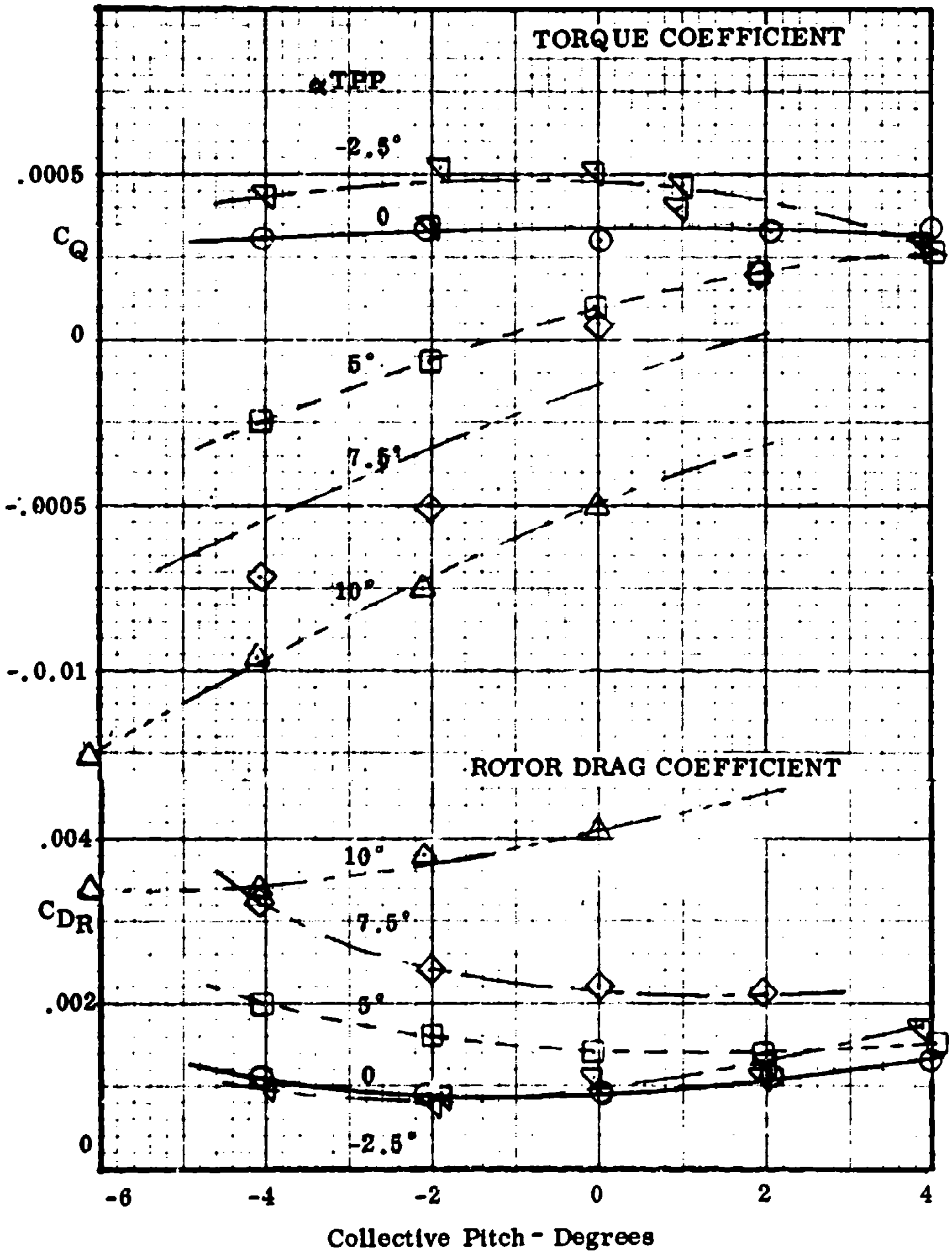
MEASURED ROTOR PERFORMANCE

μ = 1.15, 1000 r.p.m., 287 knots, $M_{1,90}$ = .79, ρ = .00085, run 42



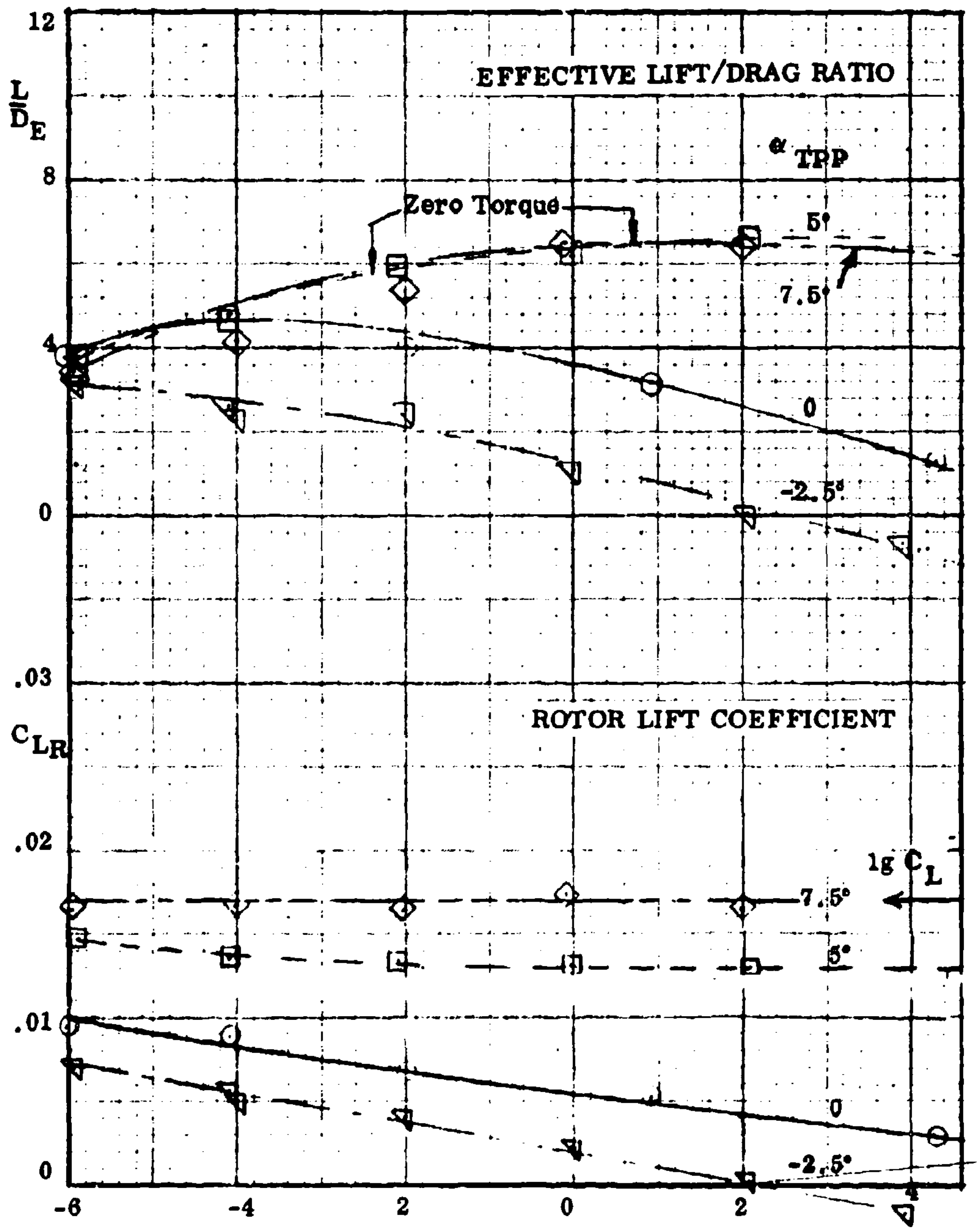
MEASURED ROTOR PERFORMANCE

μ = 1.15, 1000 r.p.m., 287 knots, $M_{1,90}$ = .79, ρ = .00085, run 42



MEASURED ROTOR PERFORMANCE

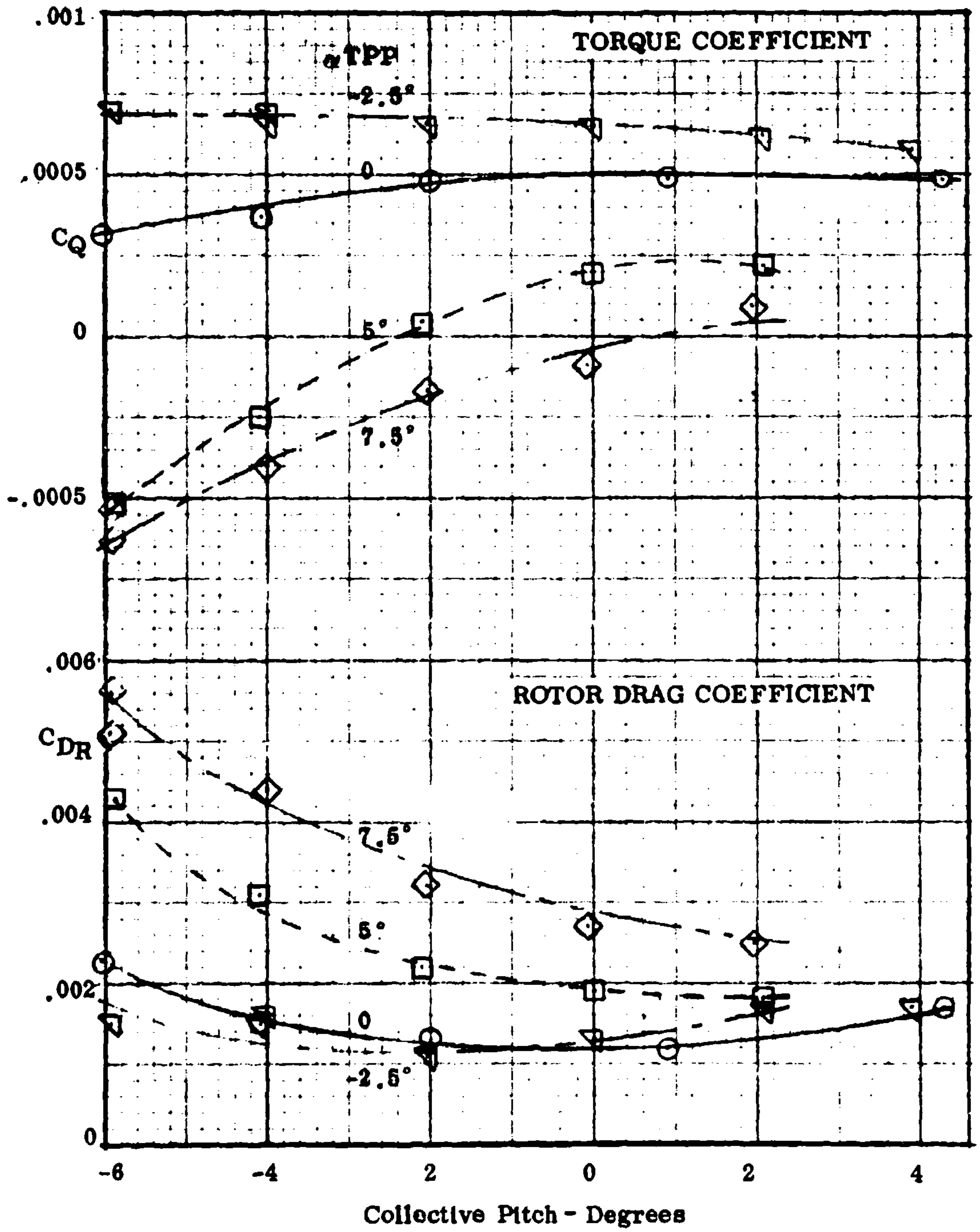
$\mu = 1.15$, 1167 r.p.m., 350 knots, $M_{1,90} = .93$, $\rho = .00084$, run 45



Collective Pitch - Degrees

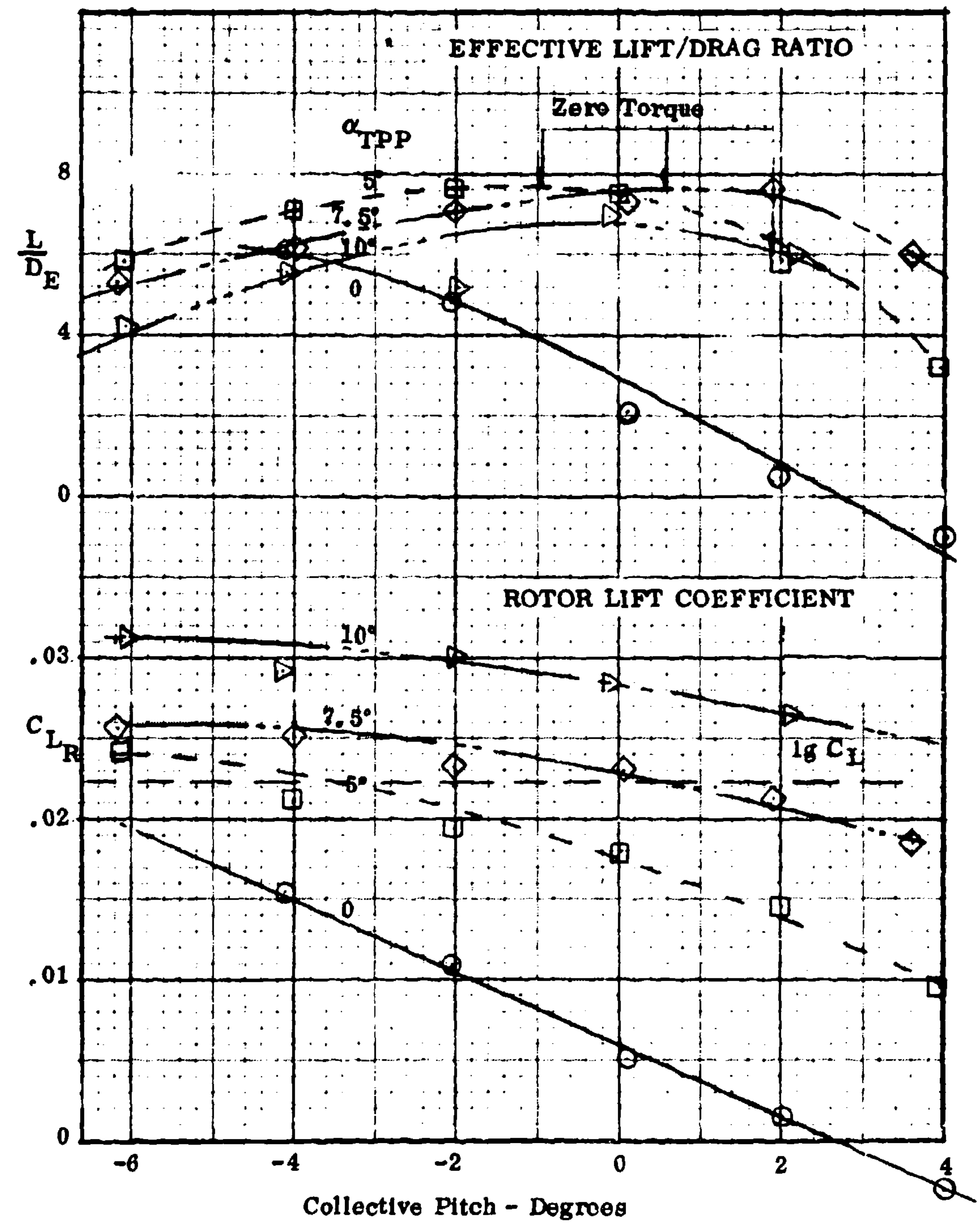
MEASURED ROTOR PERFORMANCE

$\mu = 1.15$, 1167 r.p.m., 350 knots, $M_{1,\ 90} = .93$, $\rho = .00084$, run 45



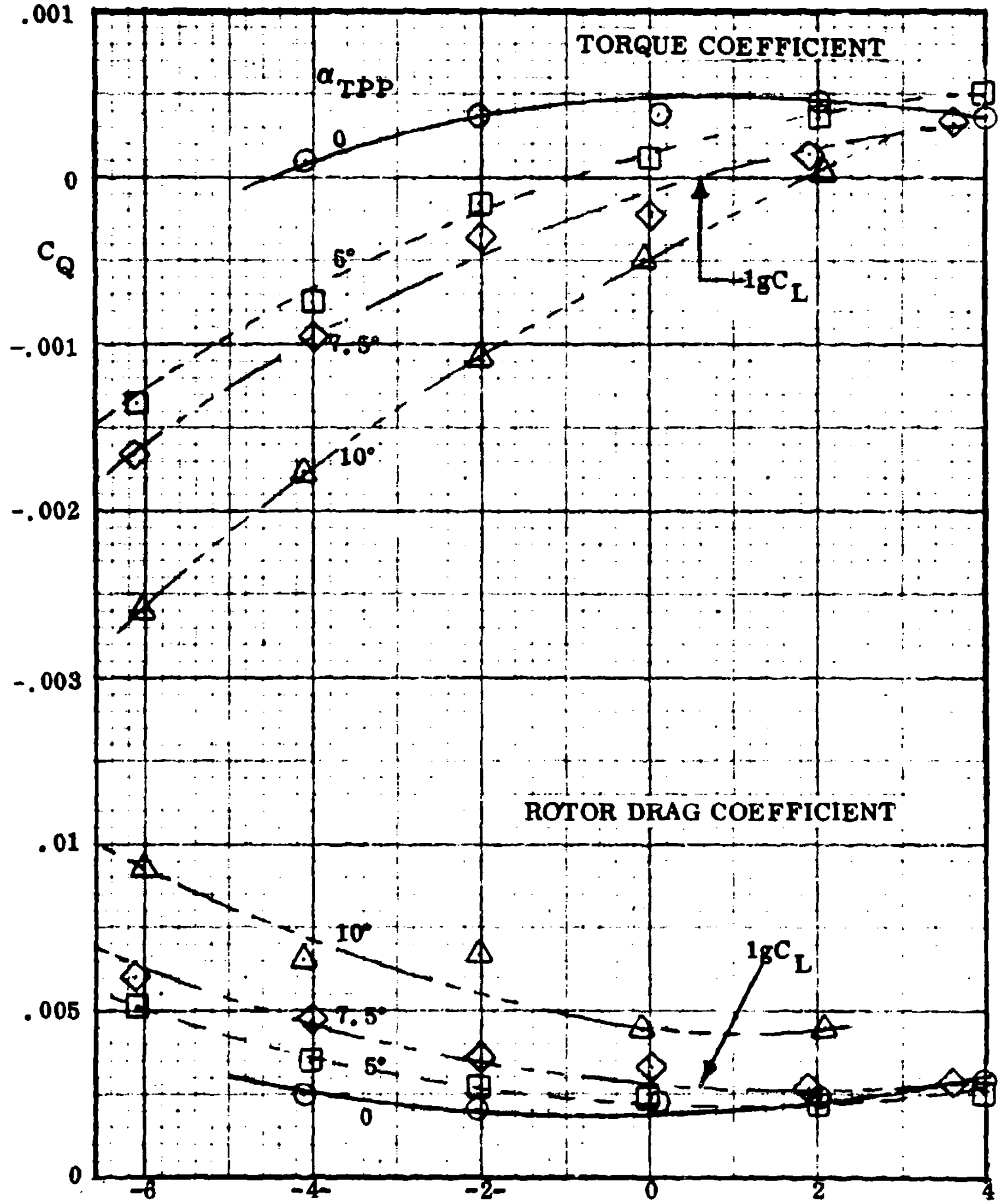
MEASURED ROTOR PERFORMANCE

$\mu = 1.40$, 833 r.p.m., 290 knots, $M_{1,90} = .73$, $\rho = .00085$, run 43



MEASURED ROTOR PERFORMANCE

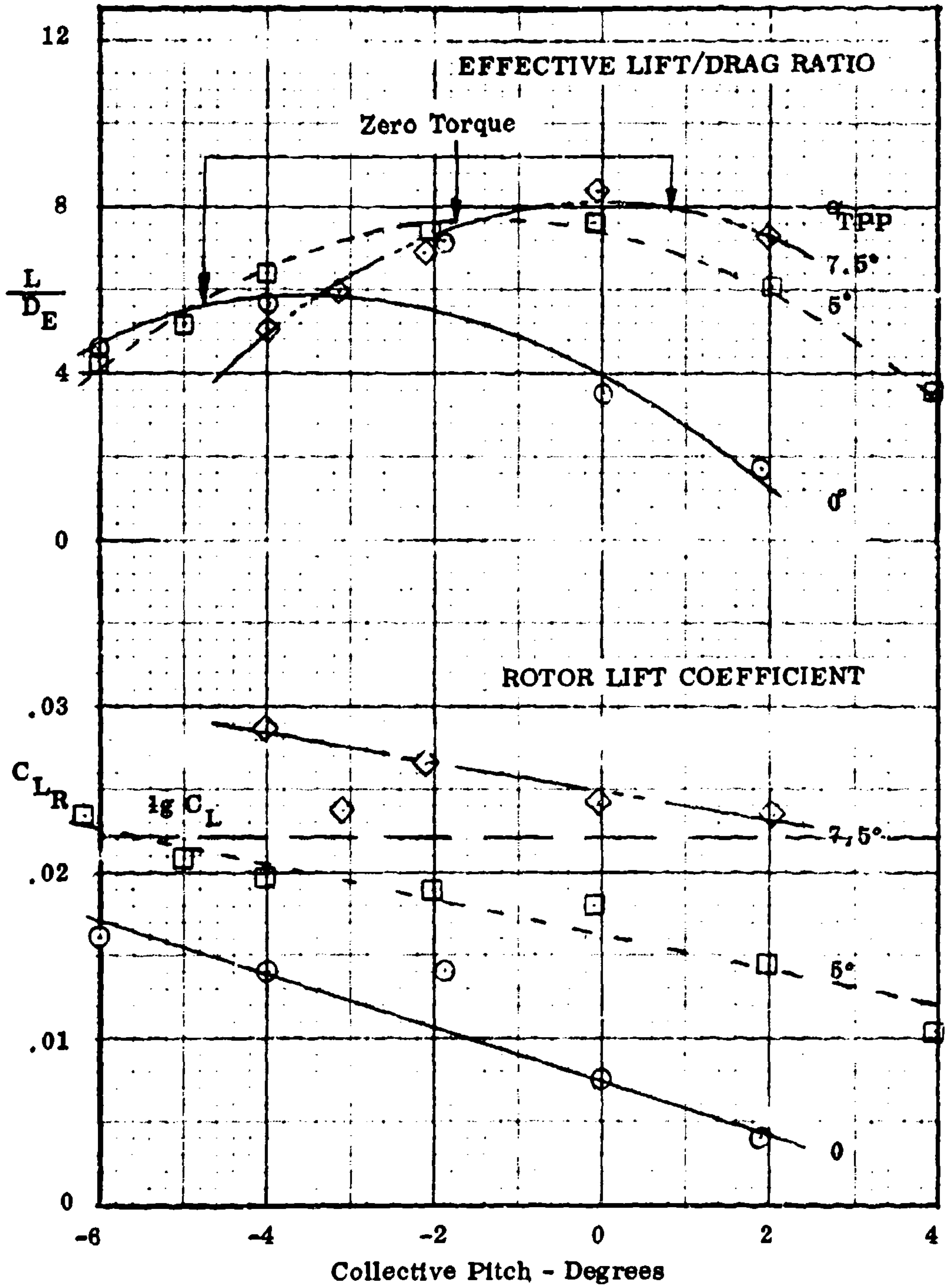
μ = 1.40, 833 r.p.m., 290 knots, $M_{1,\,90}$ = .73, ρ = .00085, run 43



Collective Pitch - Degrees

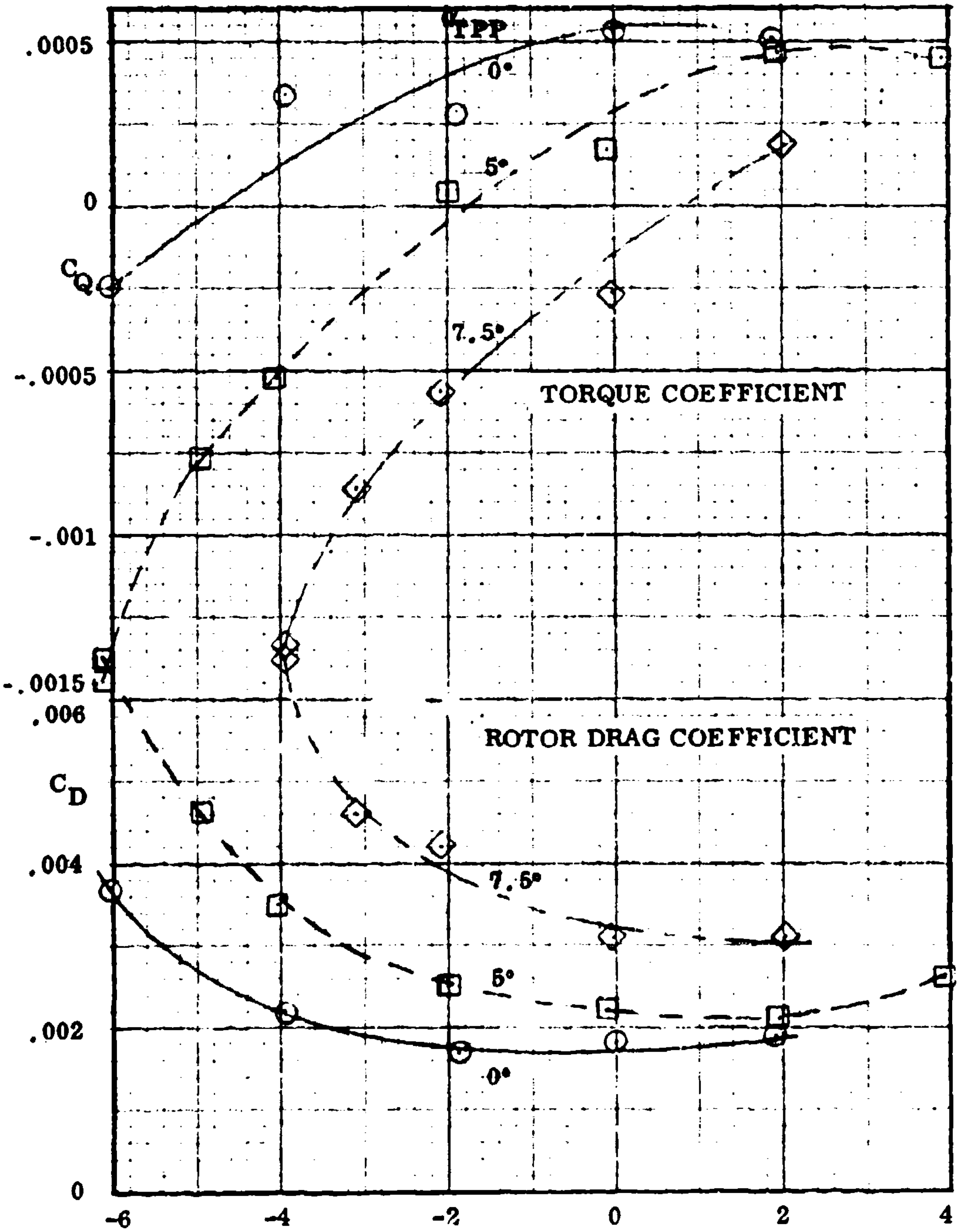
MEASURED ROTOR PERFORMANCE

$\mu = 1.40$, 970 r.p.m., 345 knots, $M_{1,90} = .86$, $\rho = .00084$, run 46



MEASURED ROTOR PERFORMANCE

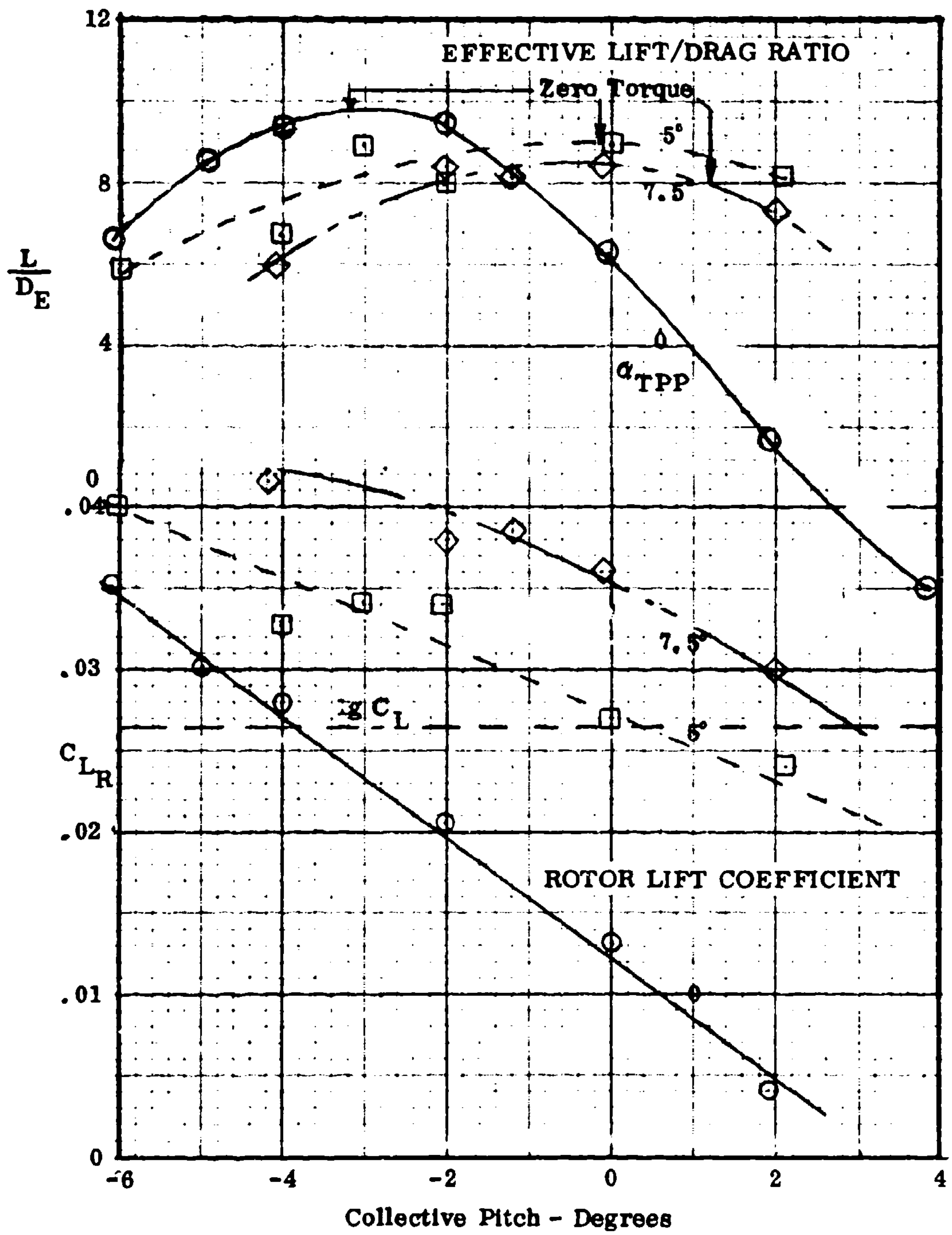
$\mu = 1.40$, 970 r.p.m., 345 knots, $M_{1,\,90} = .86$, $\rho = .00084$, run 46



Collective Pitch - Degrees

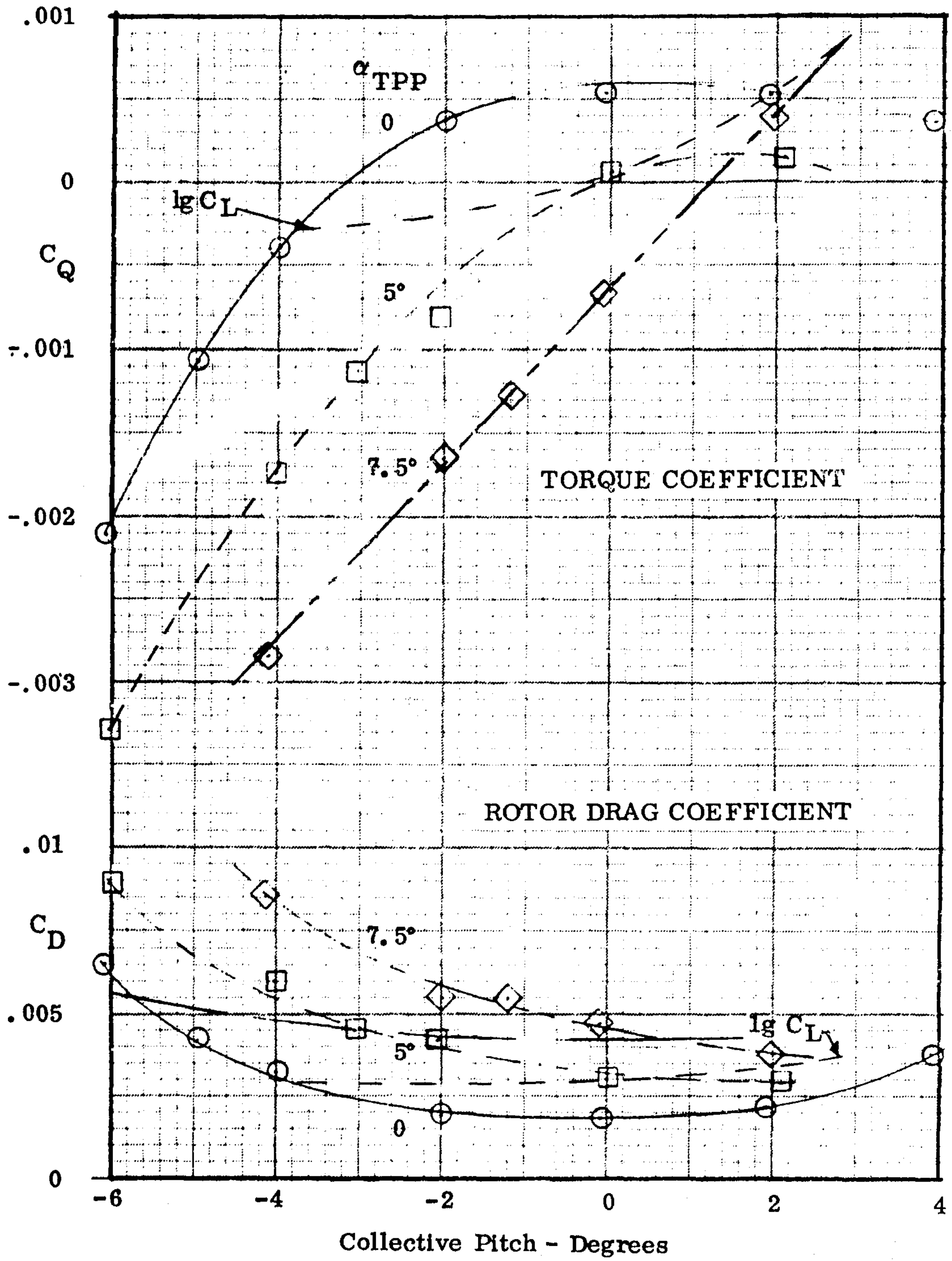
MEASURED ROTOR PERFORMANCE

$\mu = 1.66$, 833 r.p.m., 346 knots, $M_{1,90} = .81$, $\rho = .00084$, run 47



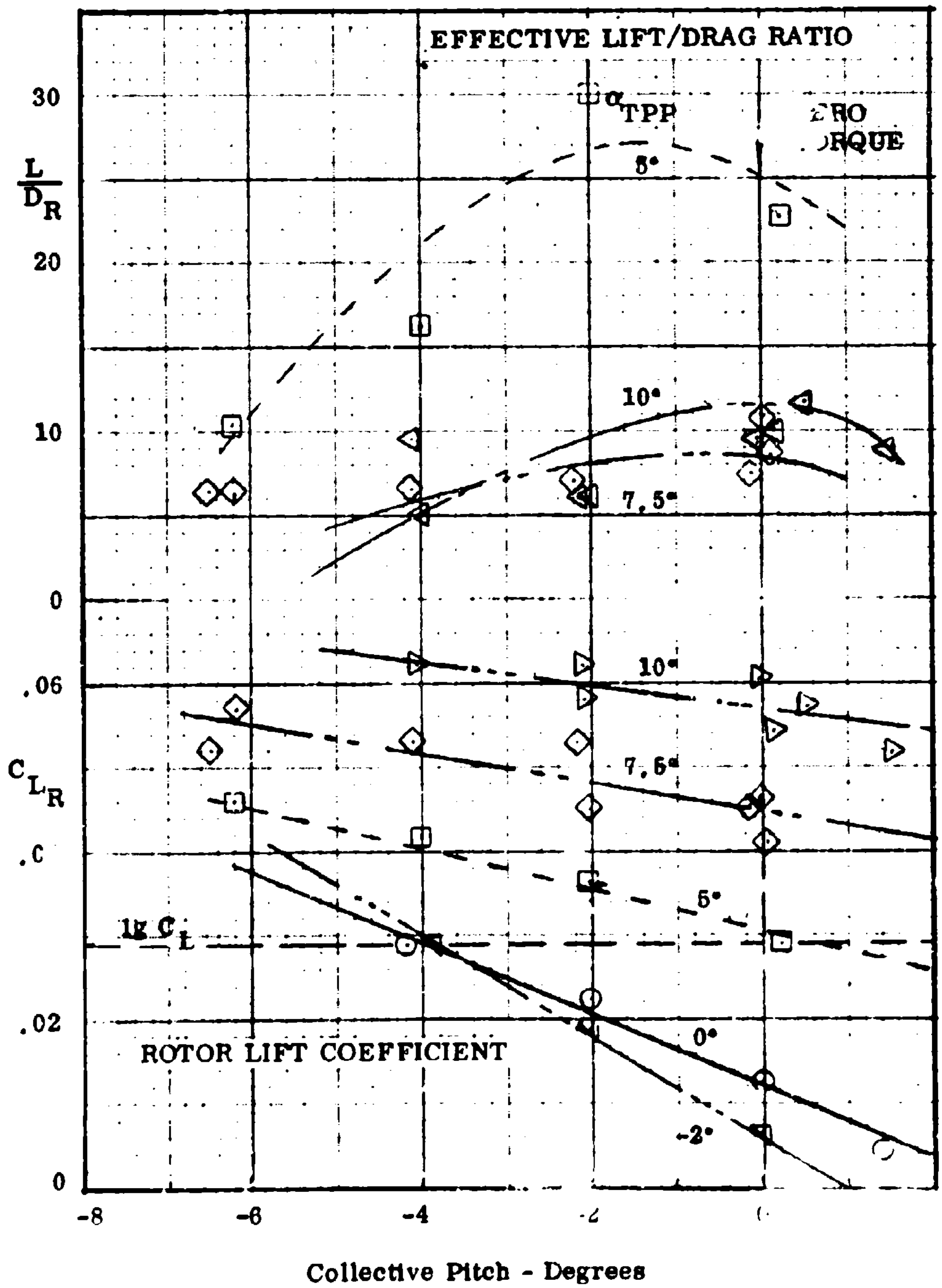
MEASURED ROTOR PERFORMANCE

μ = 1.66, 833 r.p.m., 346 knots, $M_{1,90}$ = .81, ρ = .00084, run 47



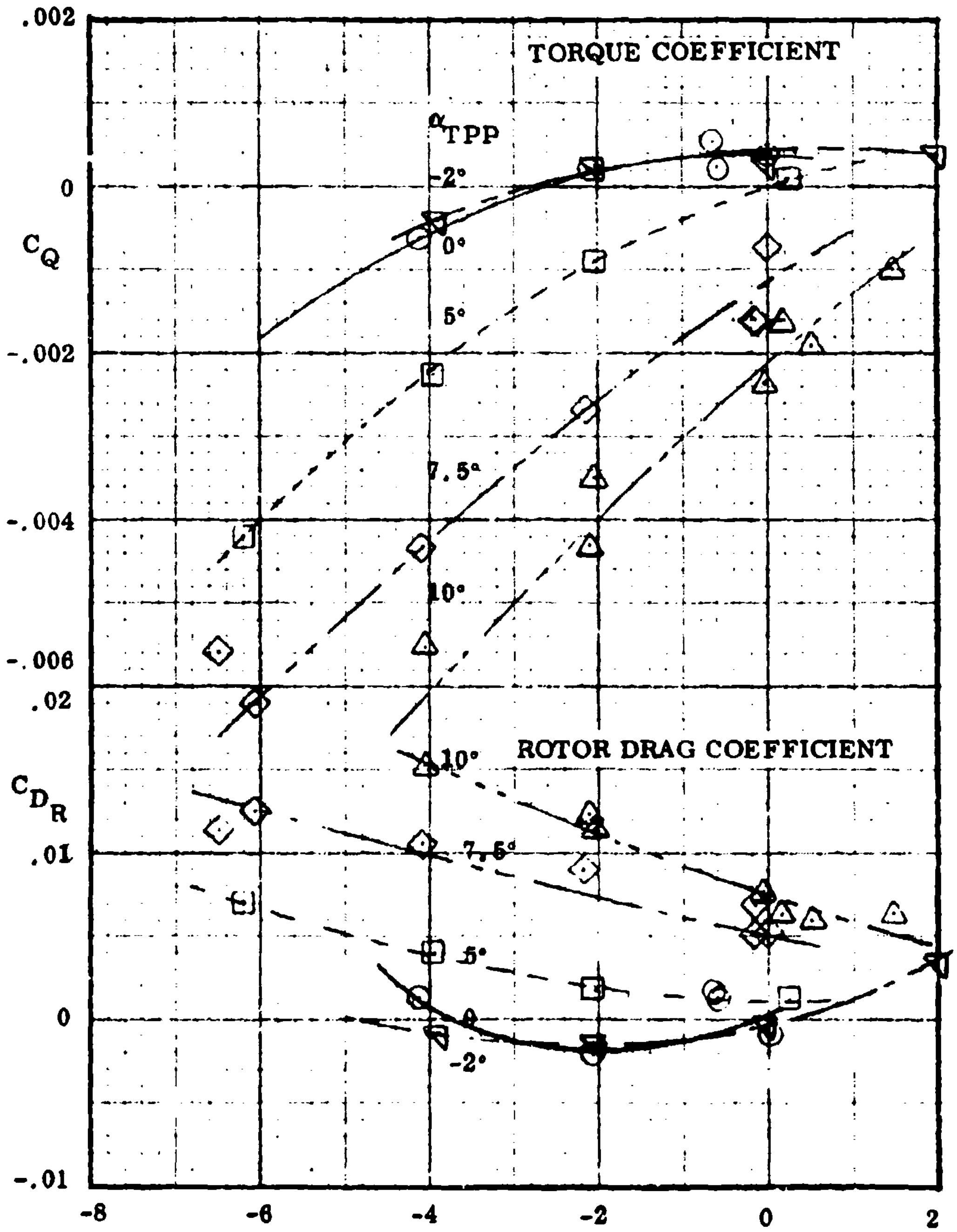
MEASURED ROTOR PERFORMANCE

μ=1.75, 656 r.p.m., 292 knots, $M_{1,\ 90}$ = .67, ρ= .00085, run 44



MEASURED ROTOR PERFORMANCE

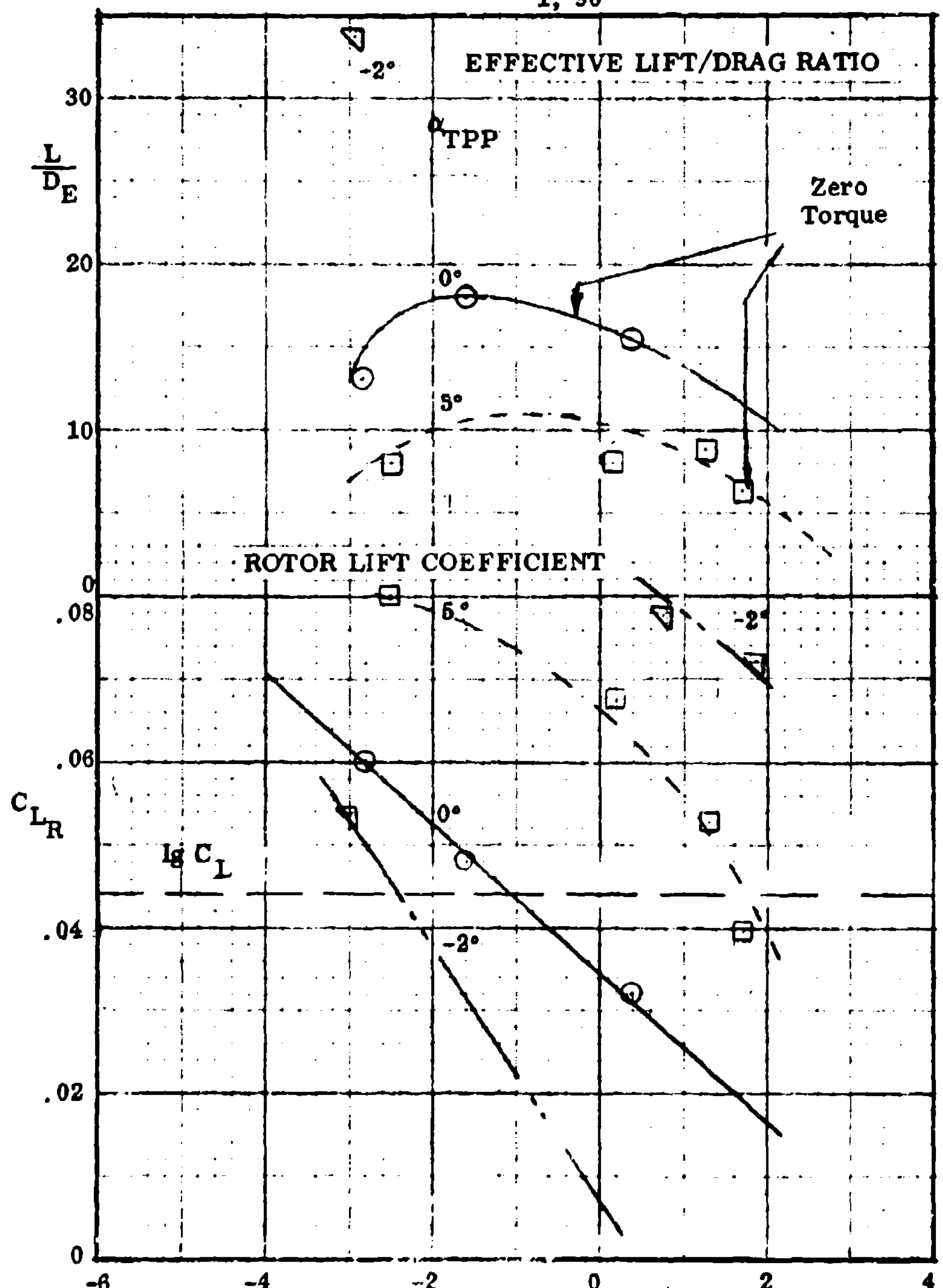
μ= 1.75, 656 r.p.m., 292 knots, $M_{1,\ 90}$ = .67, ρ= .00085, run 44



Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

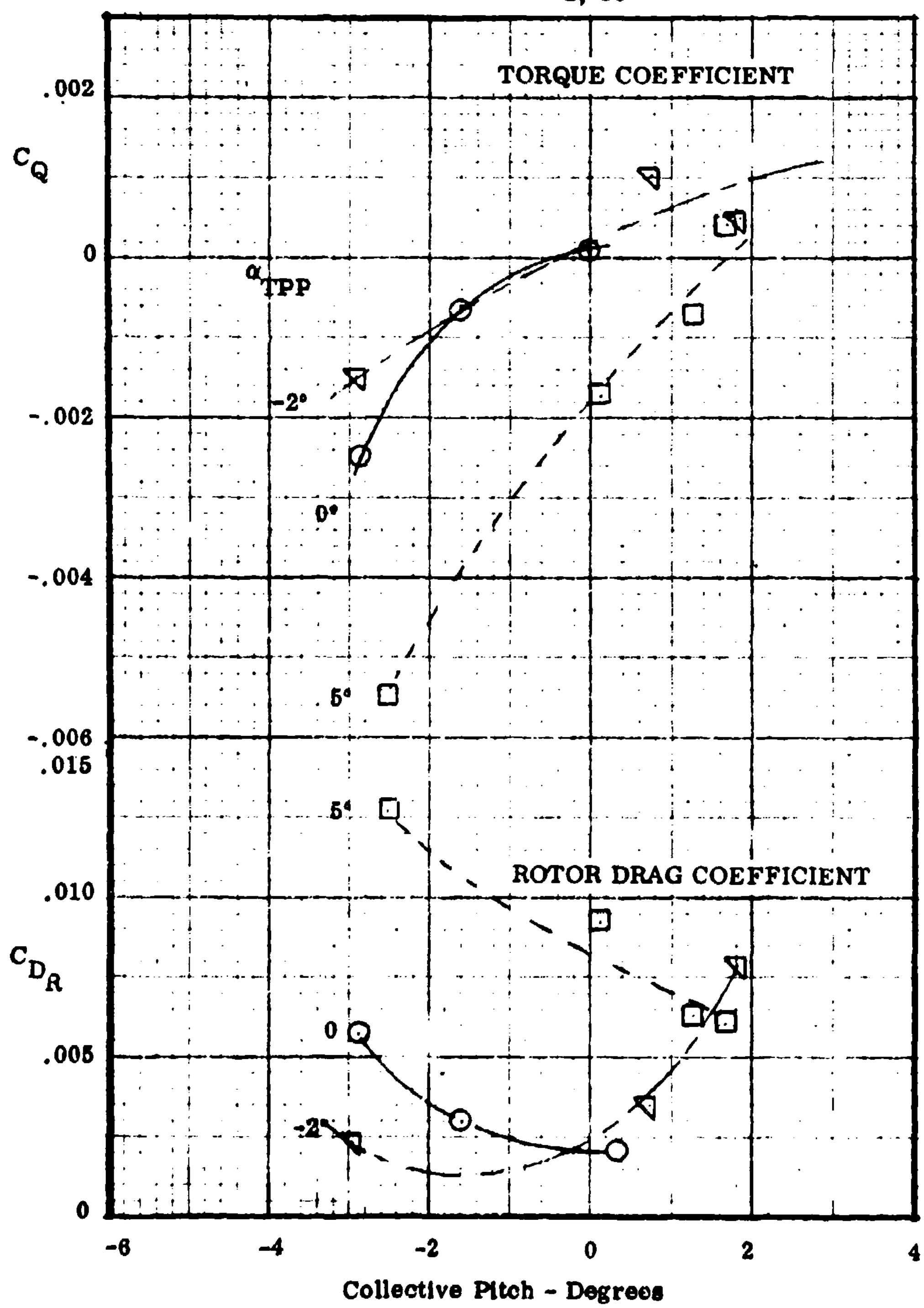
μ= 2.16, 643 r.p.m., 347 knots, $M_{1,\ 90}$ = .75, ρ= .00084, run 48



Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

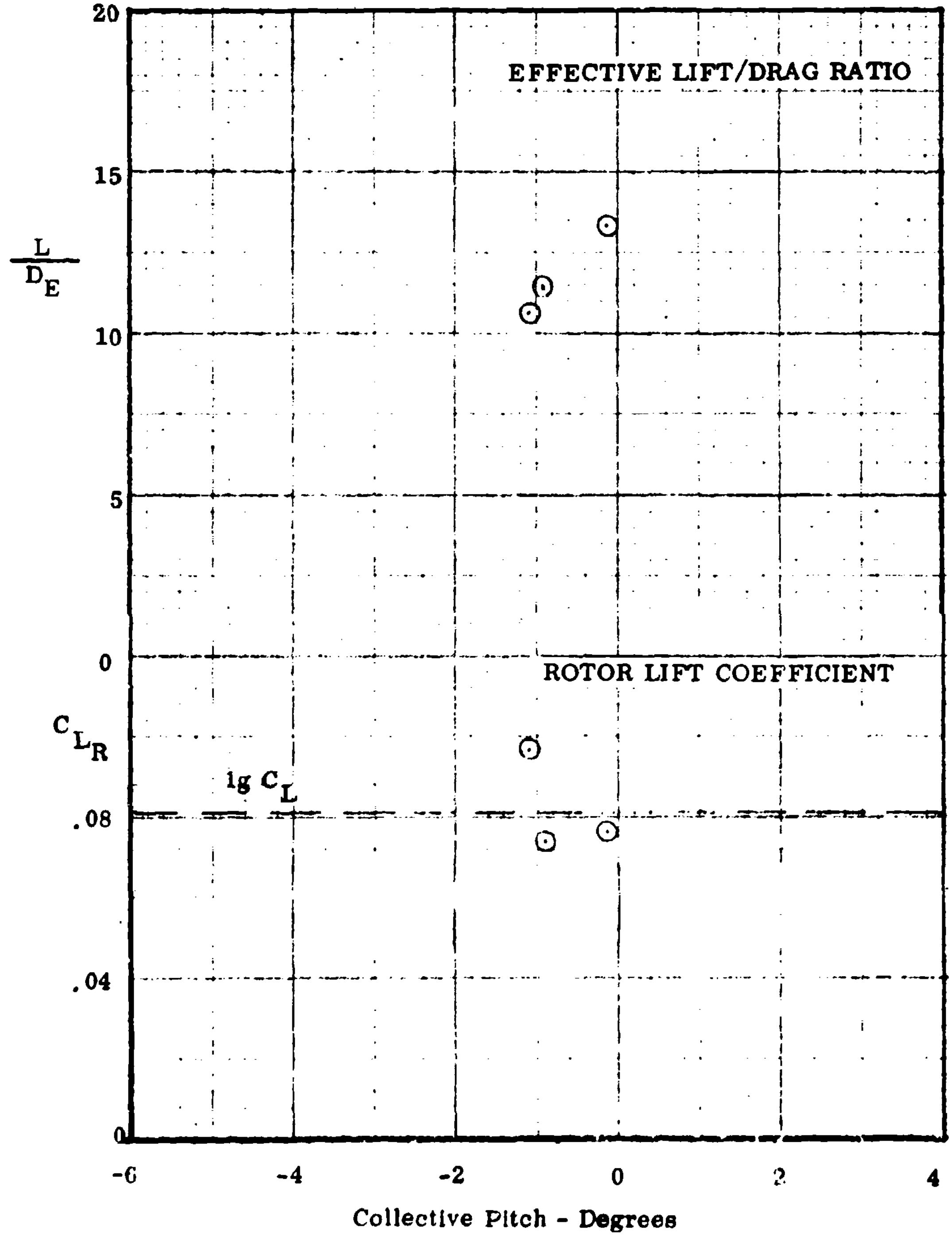
$\mu = 2.16$, 643 r.p.m., 347 knots, $M_{1,\,90} = .75$, $\rho = .00084$, run 48



MEASURED ROTOR PERFORMANCE

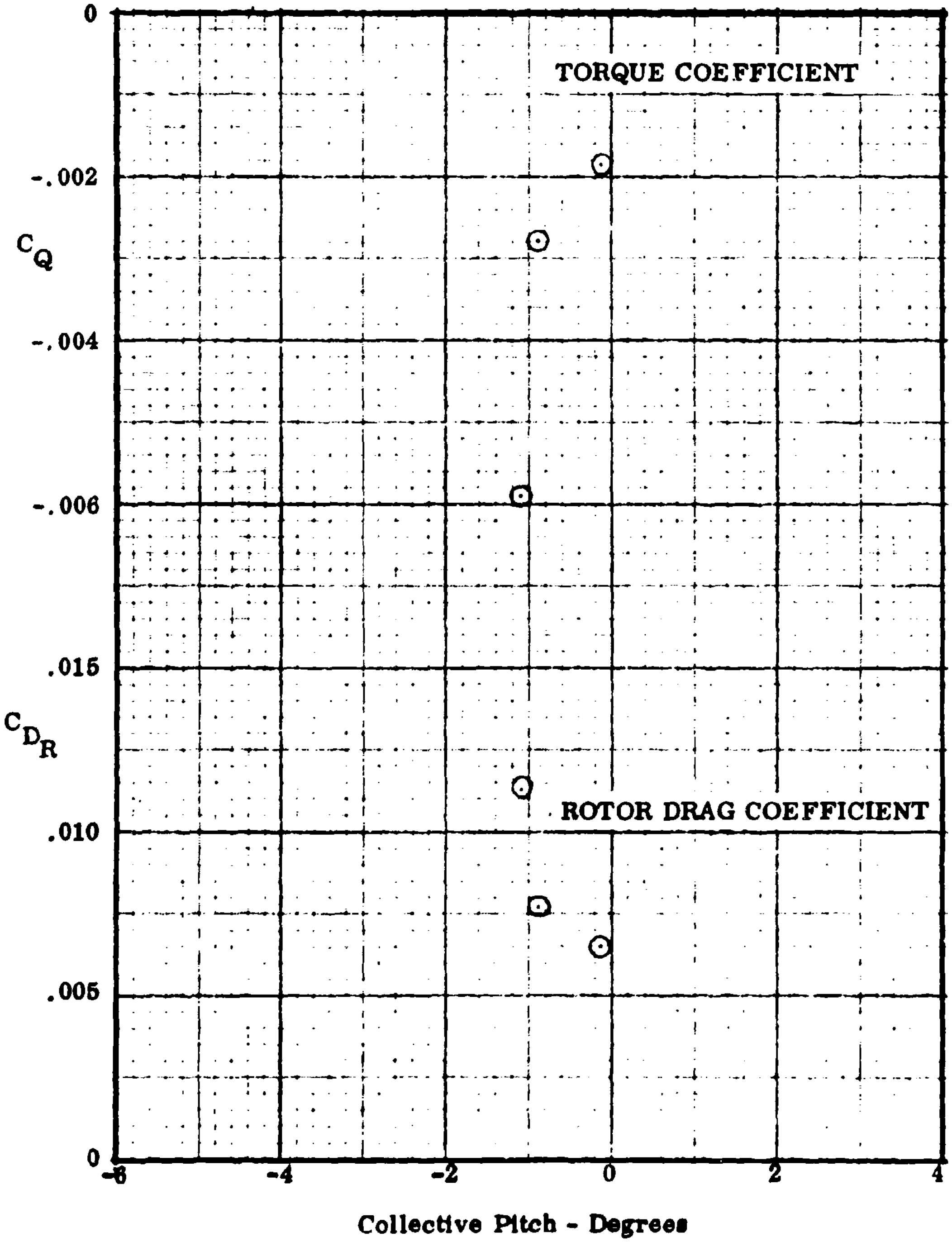
$\mu = 2.47$, 560 r.p.m., 350 knots, $M_{1,\ 90} = .72$, $\rho = .00084$, run 49

$\alpha_{TPP} = 0$



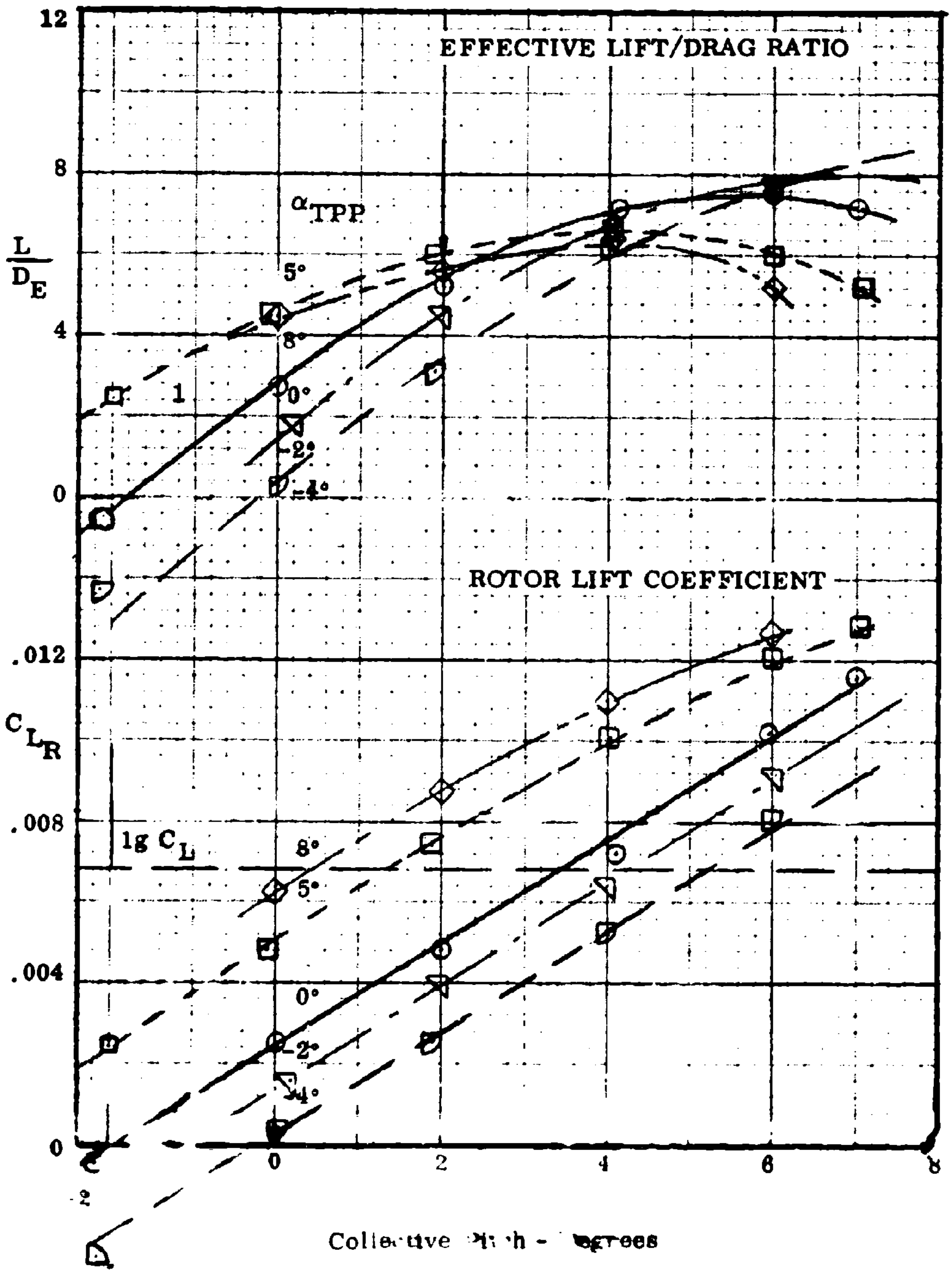
MEASURED ROTOR PERFORMANCE

$\mu = 2.47$, 560 r.p.m., 350 knots, $M_{1,\ 90} = .72$, $\rho = .00084$, run 49
$\alpha_{TPP} = 0$



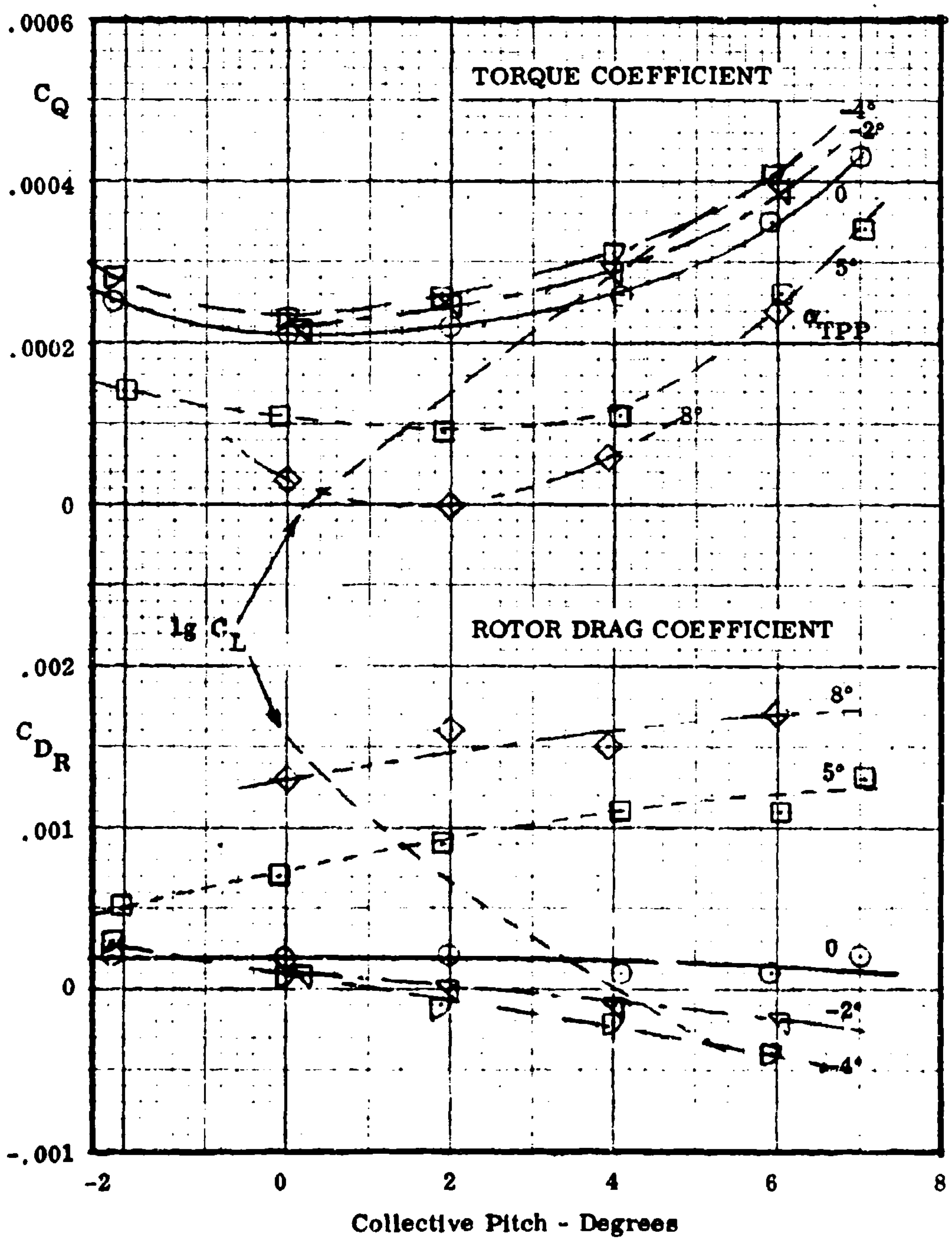
MEASURED ROTOR PERFORMANCE

μ = .29, 1670 r.p.m, 121 knots, $M_{1,\ 90}$ = .79, ρ = .0023, run 50



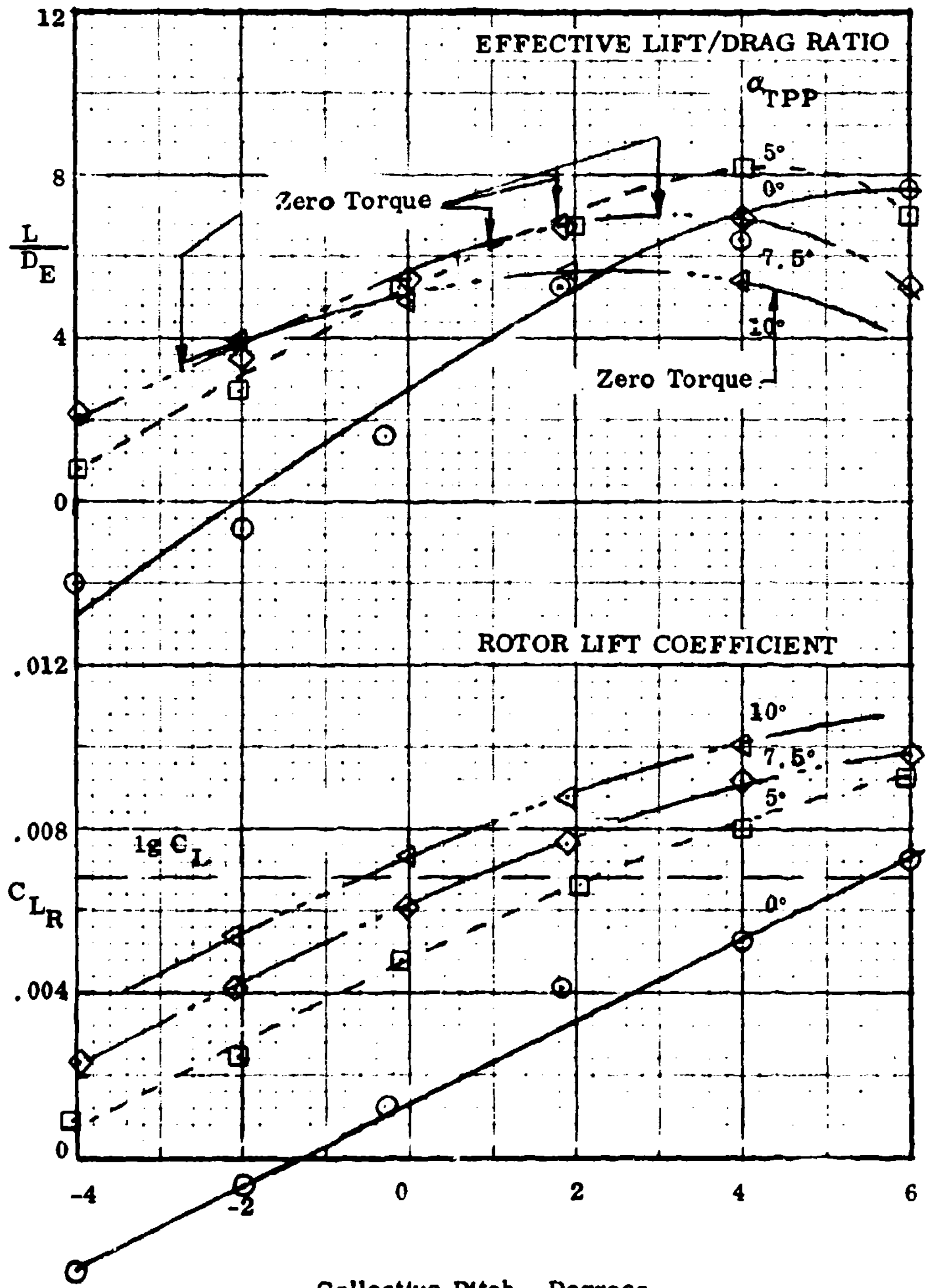
MEASURED ROTOR PERFORMANCE

μ = .29, 1670 r.p.m., 121 Knots, $M_{1,\ 90}$ = .79, ρ = .0023, run 50



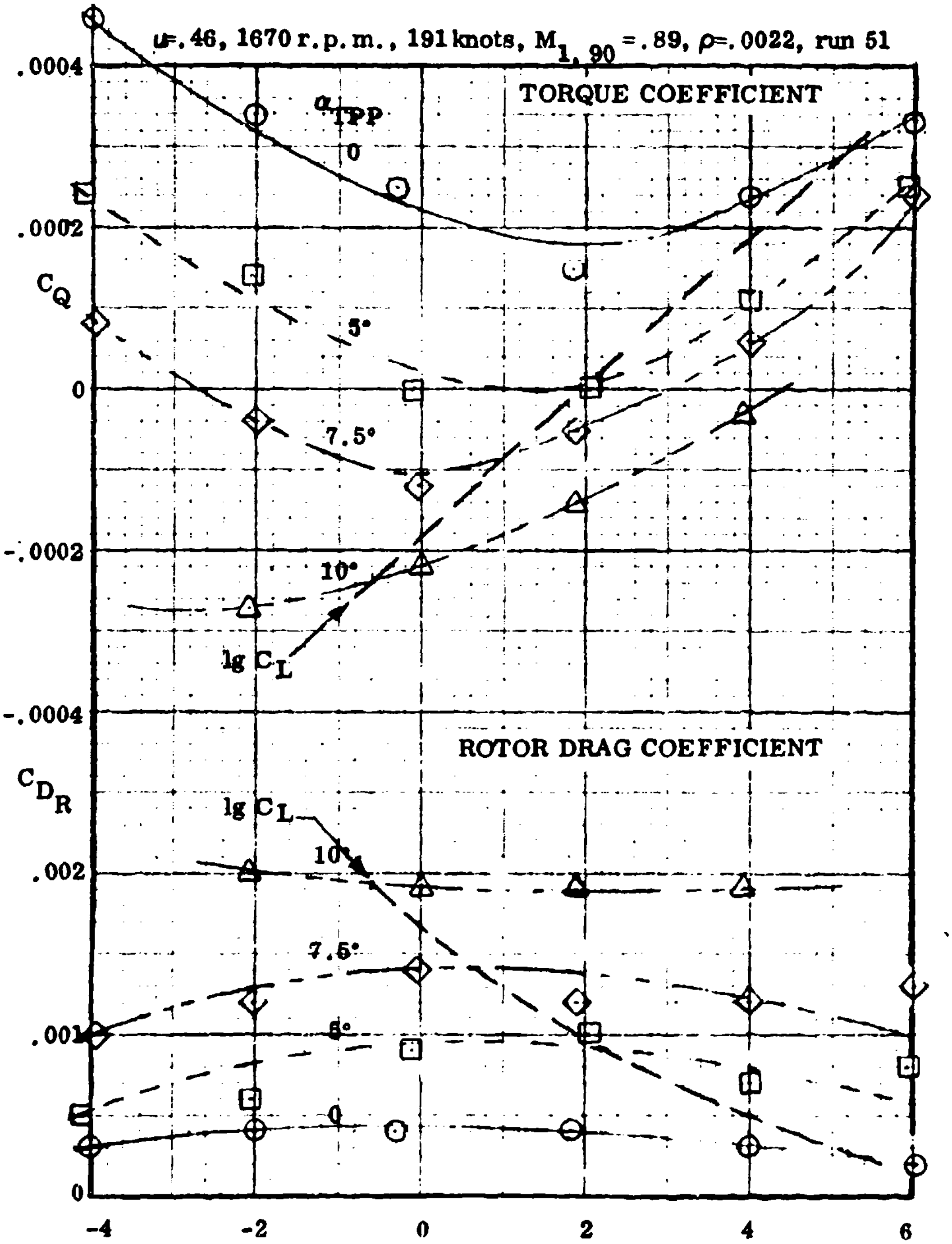
MEASURED ROTOR PERFORMANCE

μ= .46, 1670 r.p.m., 191 knots, $M_{1,\ 90}$ = .89, ρ= .0022, run 51



Collective Pitch - Degrees

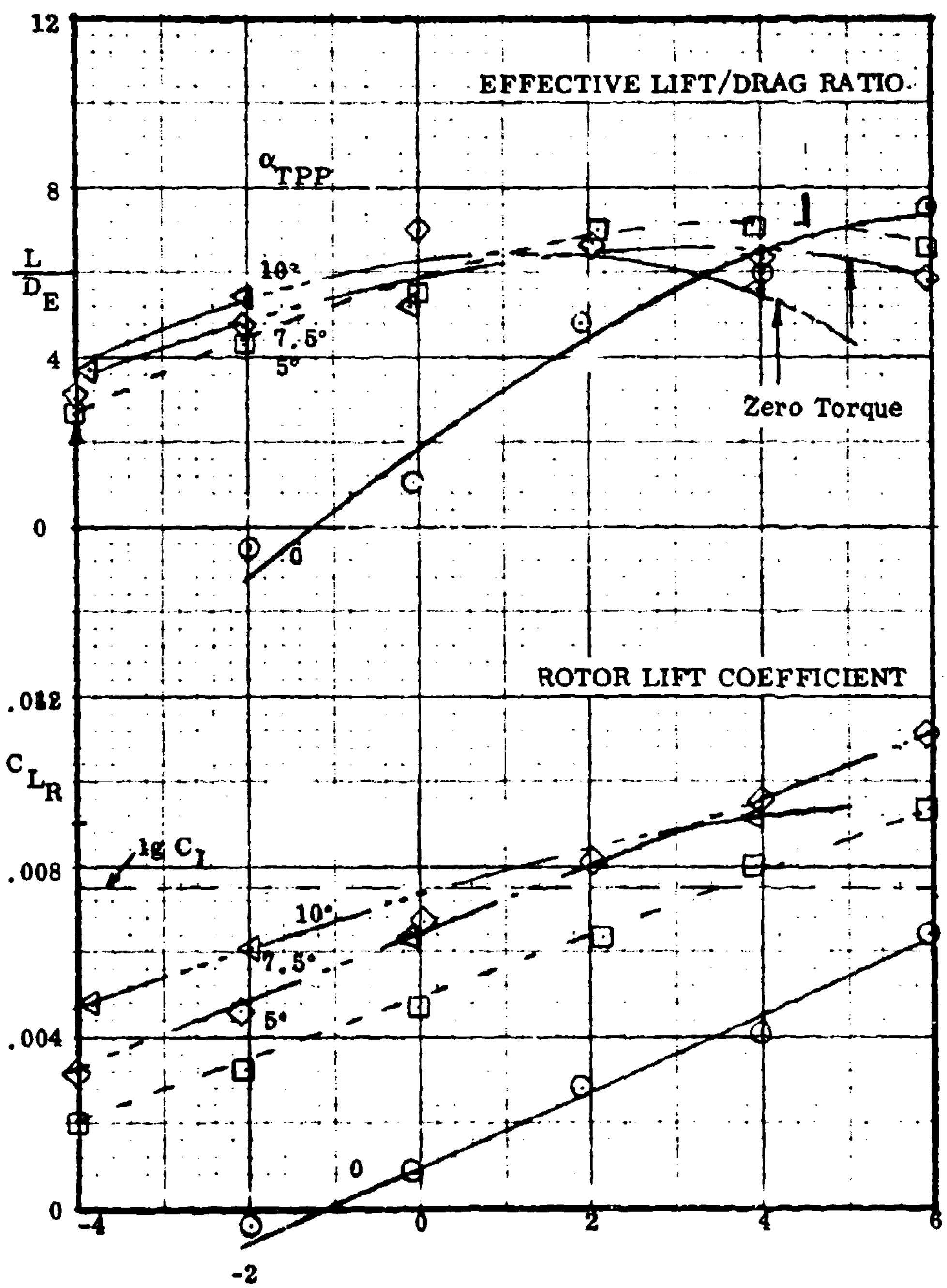
MEASURED ROTOR PERFORMANCE



Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

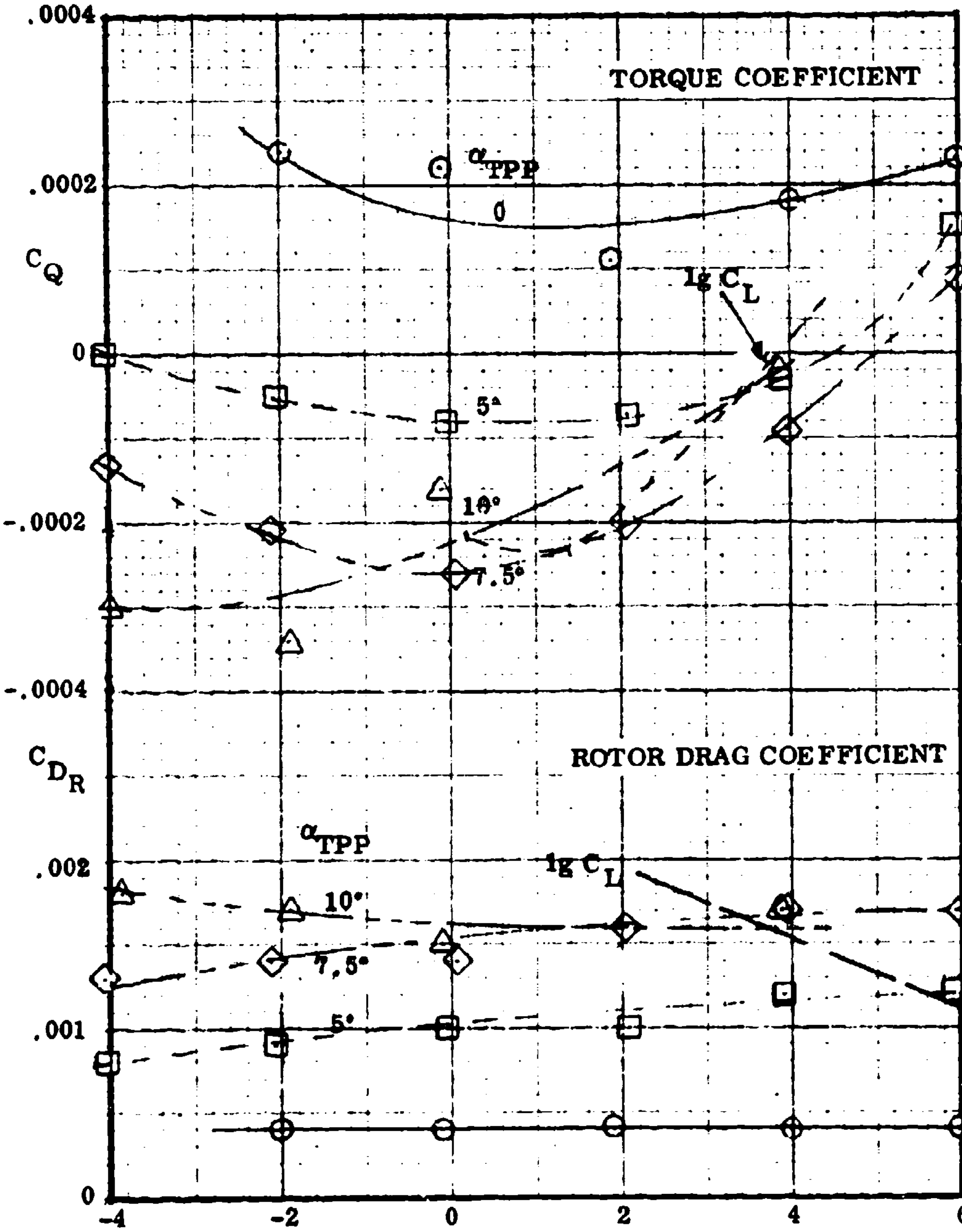
μ= .57, 1330 r.p.m., 192 knots, $M_{1,\ 90}$ =.76, ρ= .0022, run 52



Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

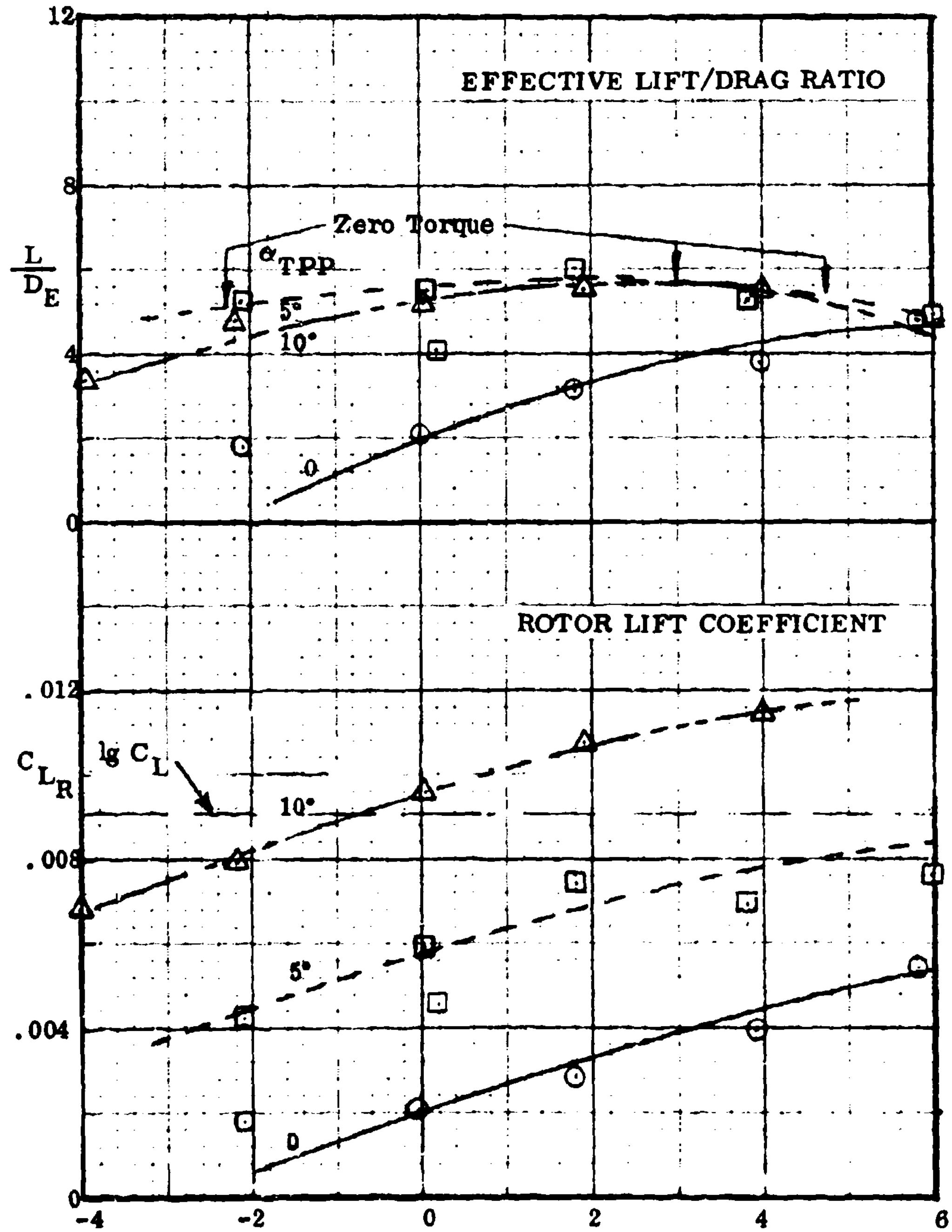
μ = .57, 1330 r.p.m., 192 knots, $M_{1,\,90}$ =.76, ρ = .0022, run 52



Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

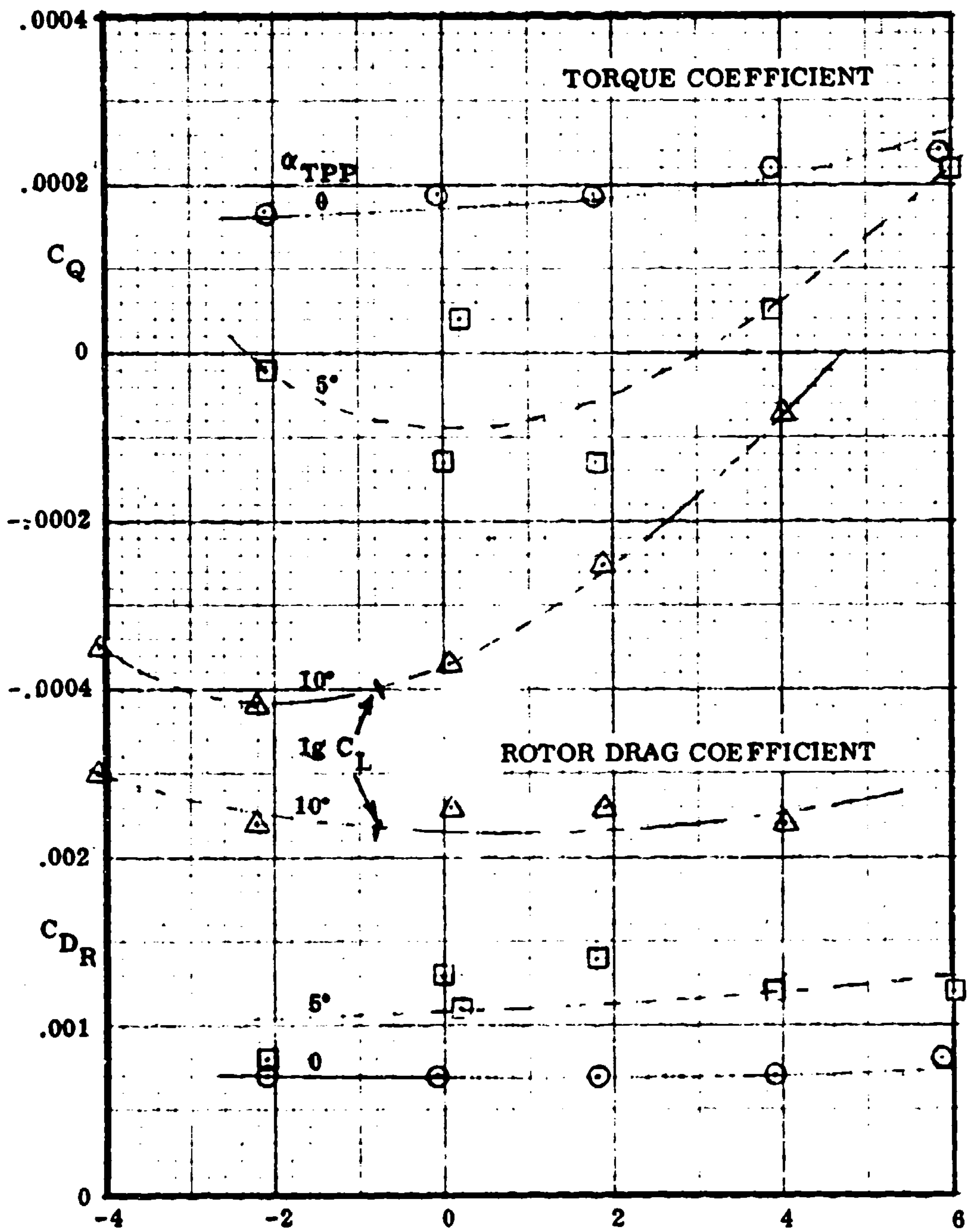
$\mu = .72$, 1350 r.p.m., 243 knots, $M_{1,90} = .61$, $\rho = .0021$, run 57



Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

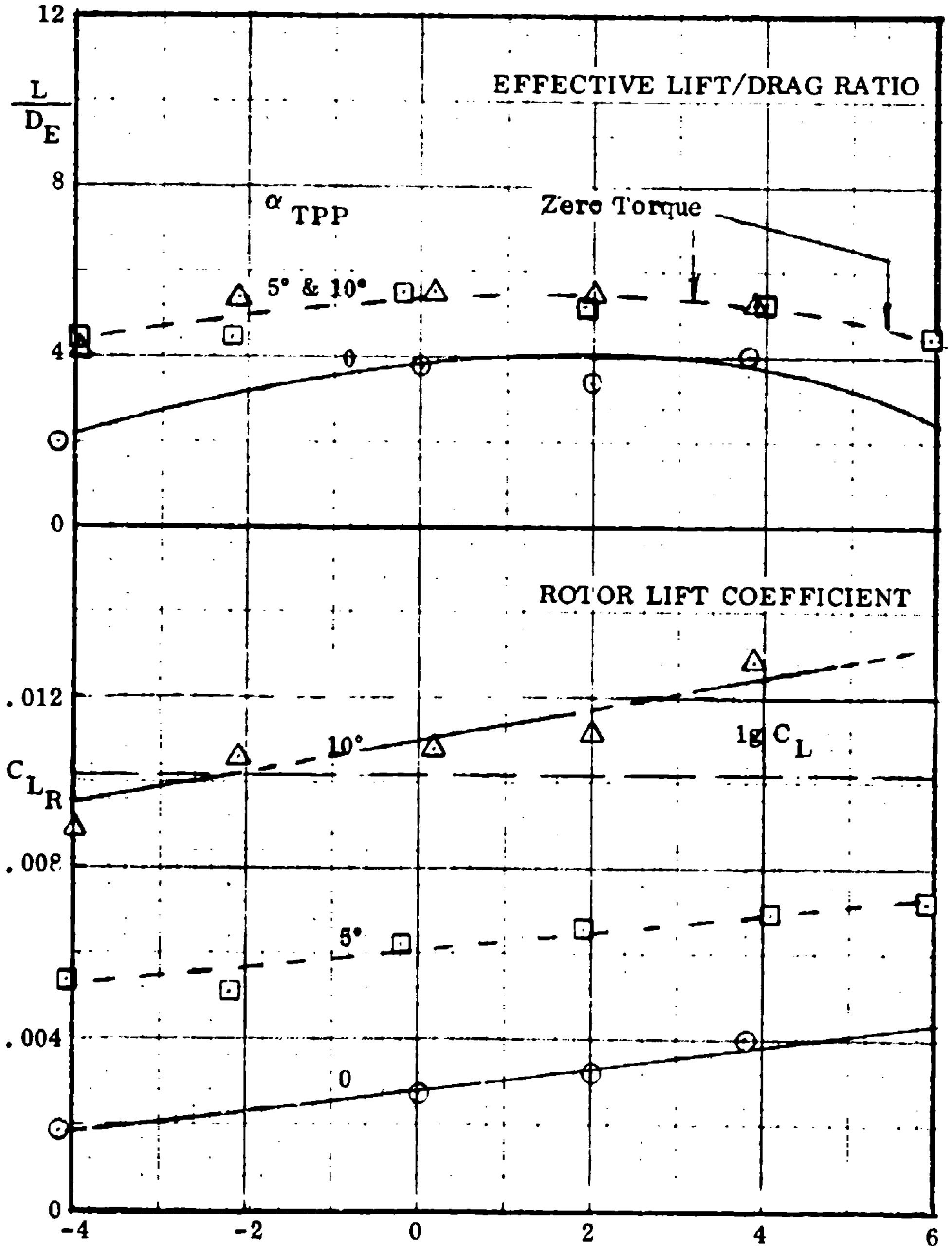
$\mu = .72$, 1350 r.p.m., 243 knots, $M_{1,90} = .61$, $\rho = .0021$, run 57



Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

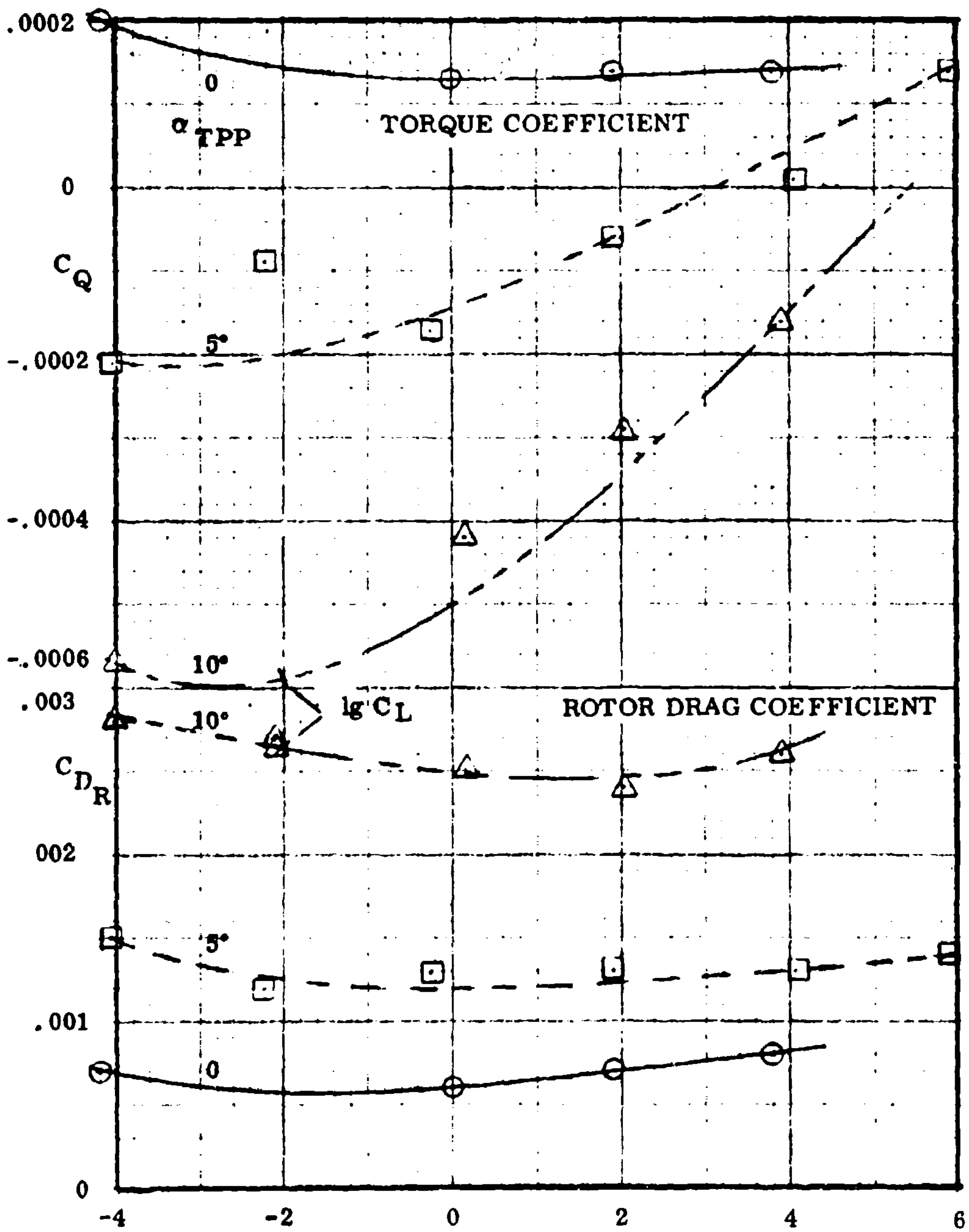
$\mu = .82$, 1170 r.p.m., 243 knots, $M_{1,90} = .65$, $\rho = .0021$, run 56



Collective Pitch - Degrees

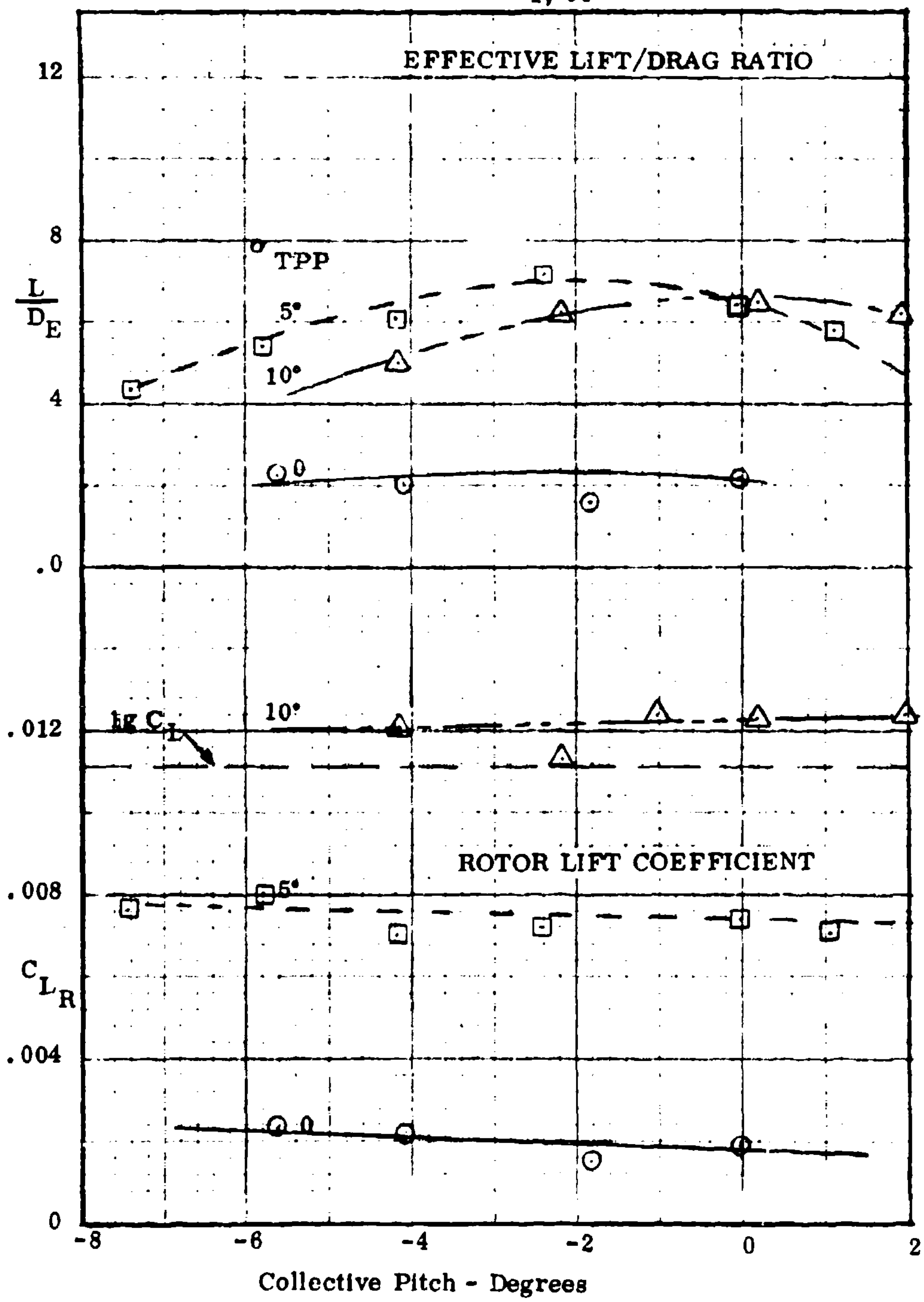
MEASURED ROTOR PERFORMANCE

μ = .82, 1170 r.p.m., 243 knots, $M_{1,90}$ = .65, ρ = .0021, run 56



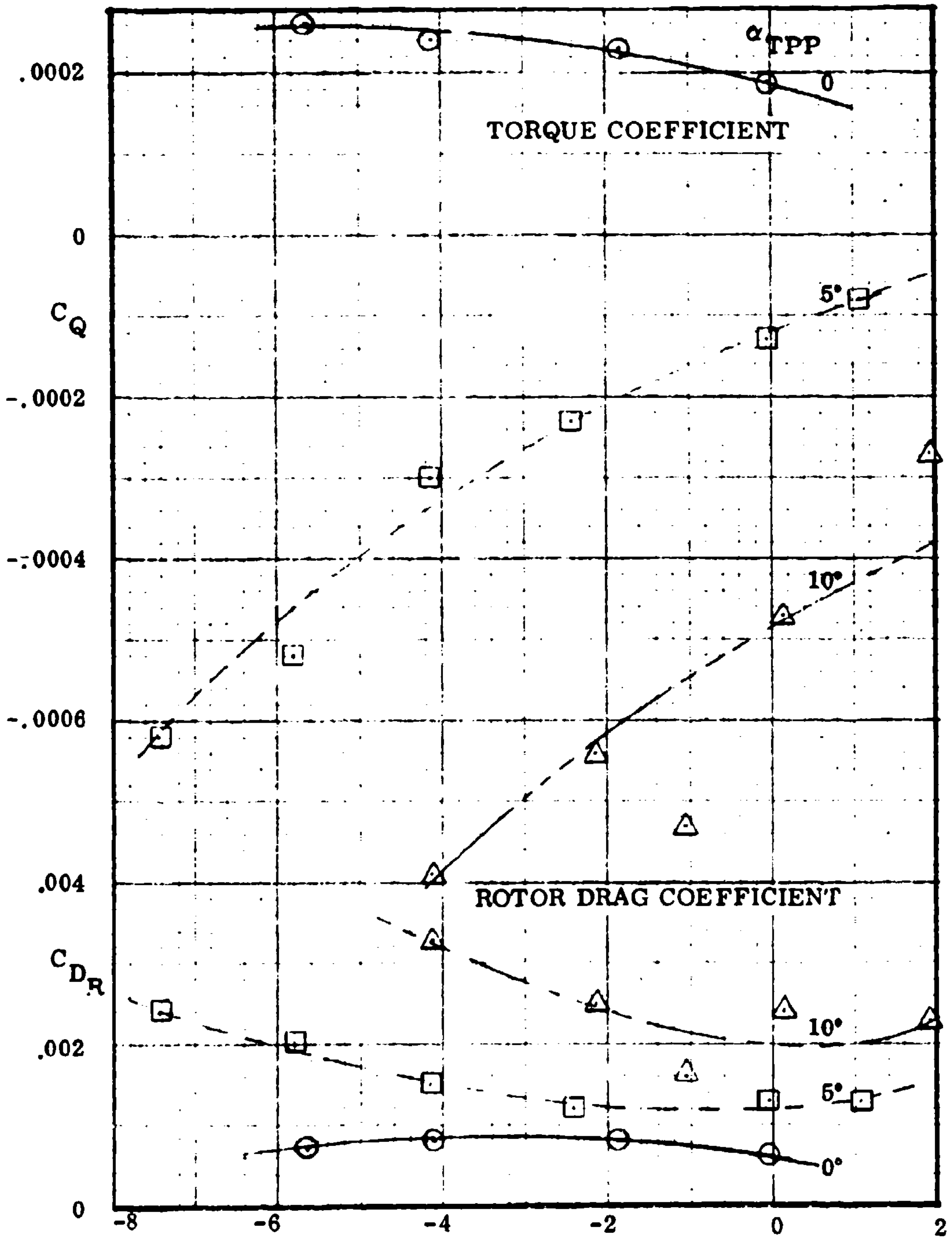
Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE
μ = .94, 1050 r.p.m., 243 knots, $M_{1,\ 90}$ = .68, ρ = .0021, run 55



MEASURED ROTOR PERFORMANCE

$\mu = .94$, 1050 r.p.m., 243 knots, $M_{1,90} = .68$, $\rho = .0021$, run 55

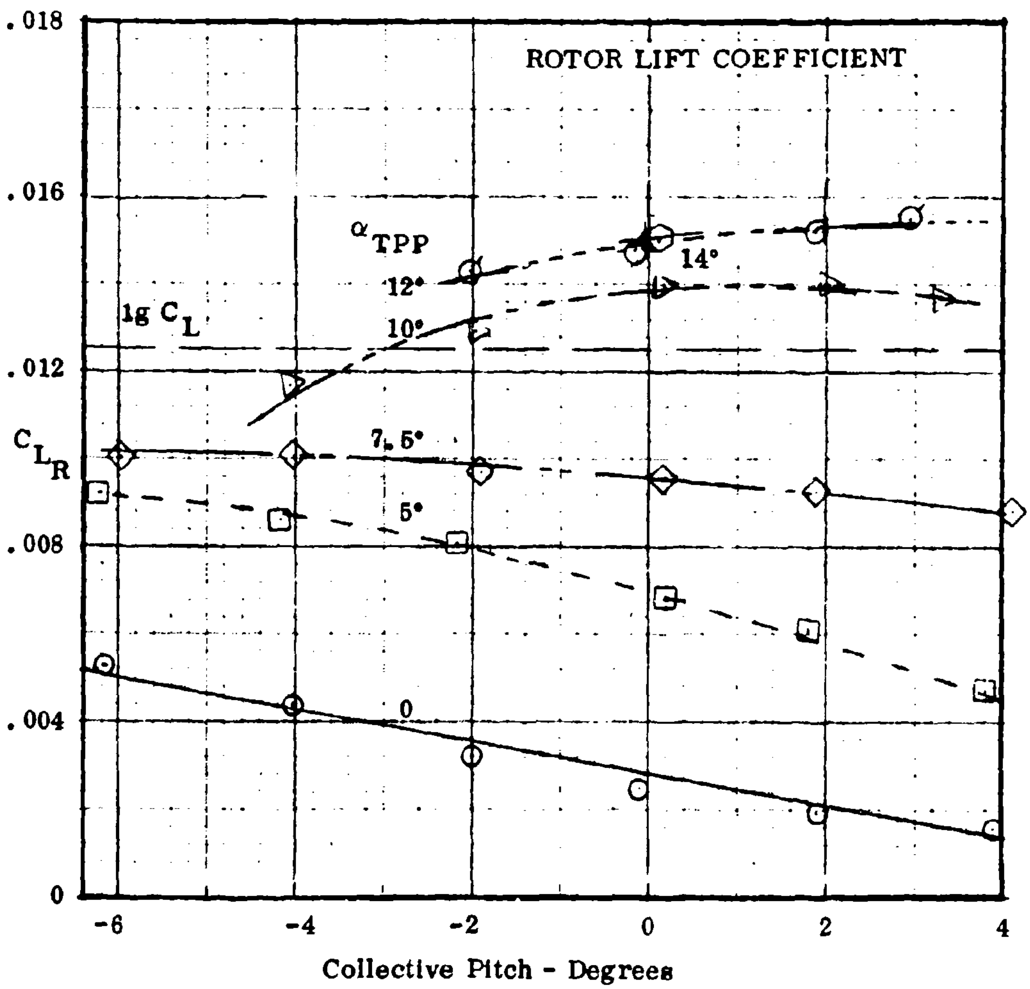


Collective Pitch - Degrees

FAIRCHILD
REPUBLIC DIVISION

MEASURED ROTOR PERFORMANCE

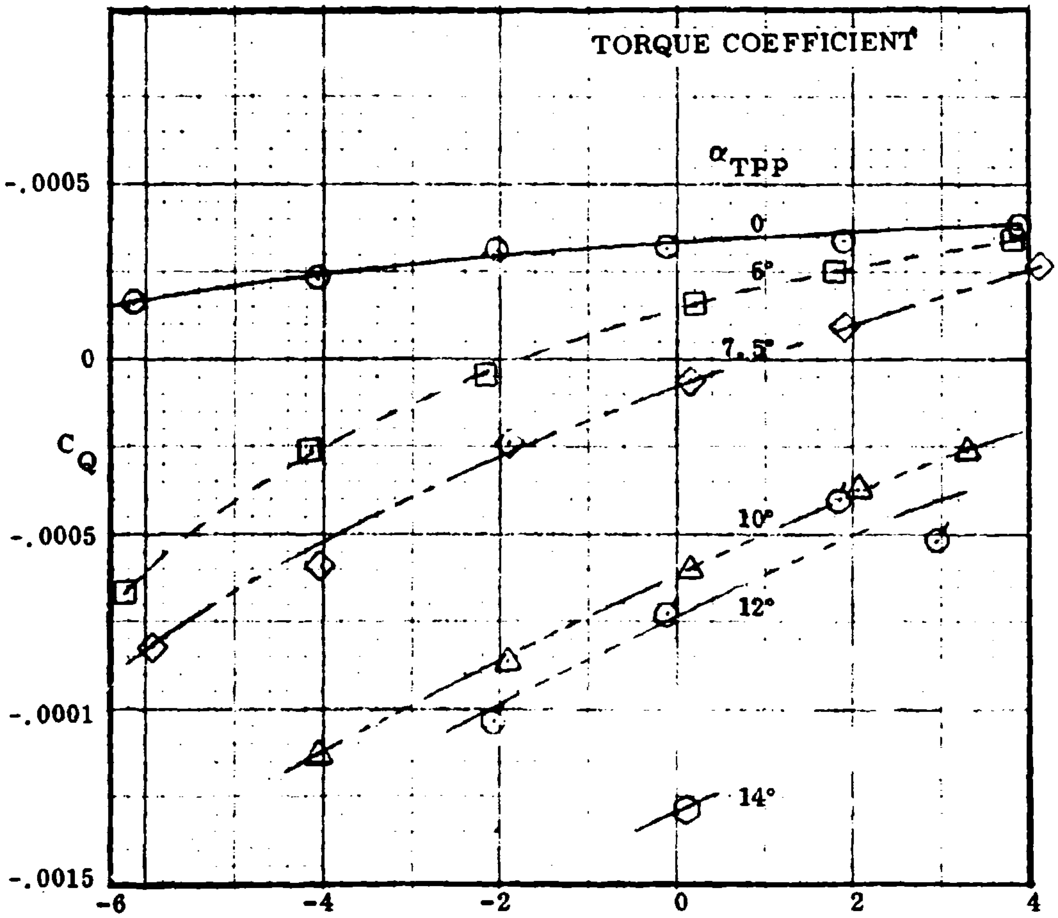
μ = 1.00, 1170 r.p.m., 295 knots, $M_{1,90}$ = .85, ρ = .0020, run 59



MEASURED ROTOR PERFORMANCE

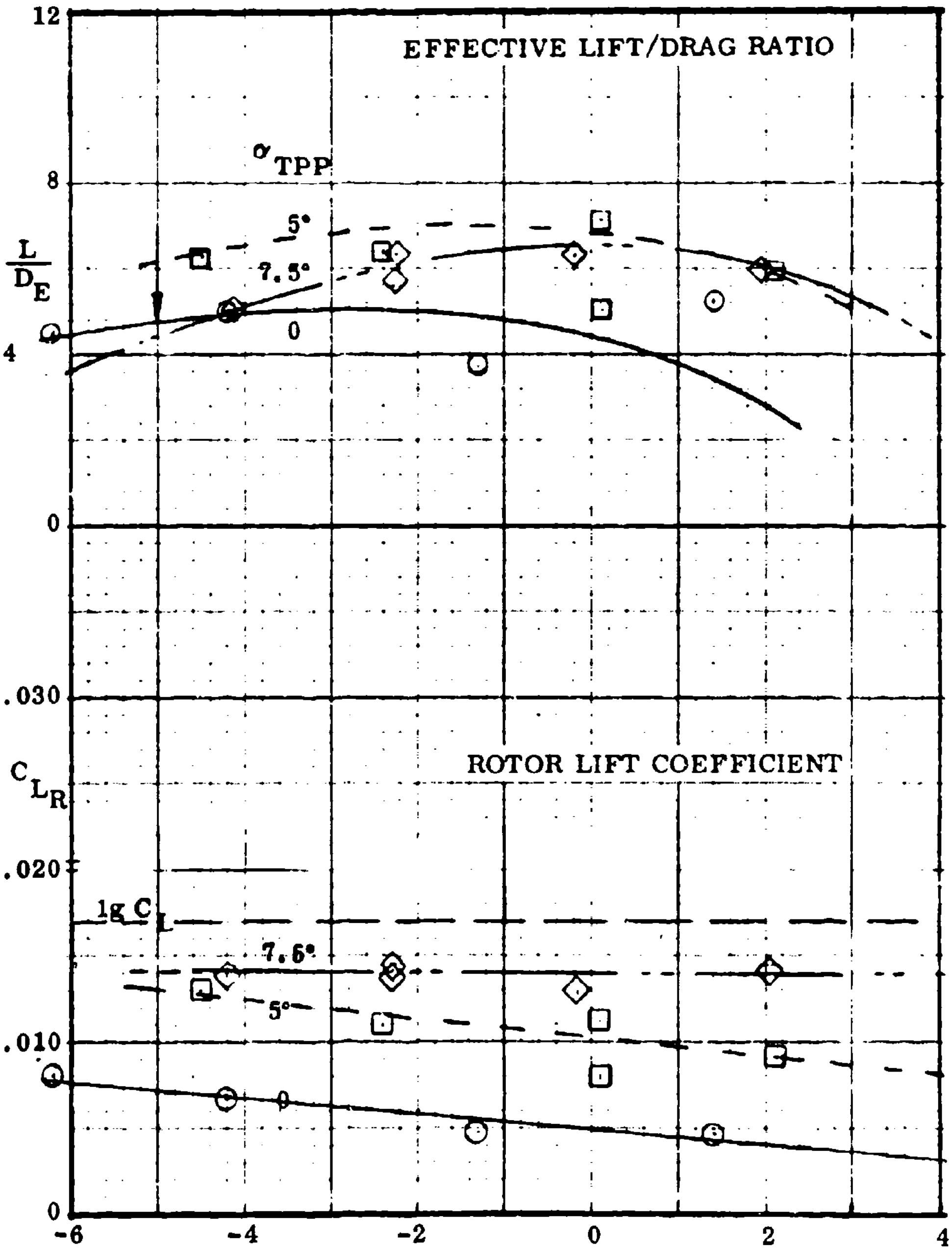
μ = 1.00, 1170 r.p.m., 295 knots, $M_{1,90}$ = .85, ρ = .0020, run 59

(Drag data not available)



Collective Pitch - Degrees

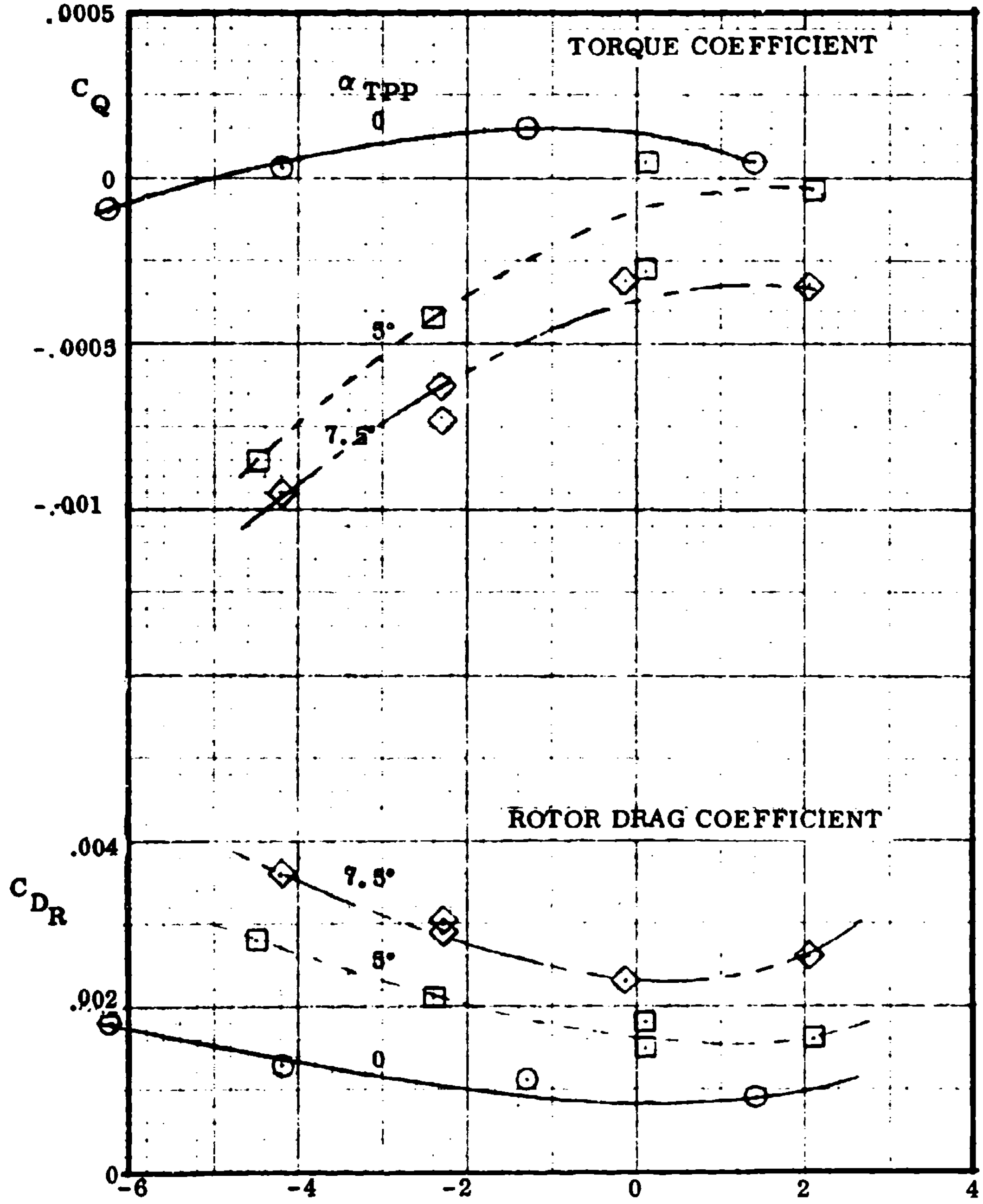
MEASURED ROTOR PERFORMANCE
μ = 1.15, 833 r.p.m., 239 knots, $M_{1,90}$ = .66, ρ = .0021, run 54



Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

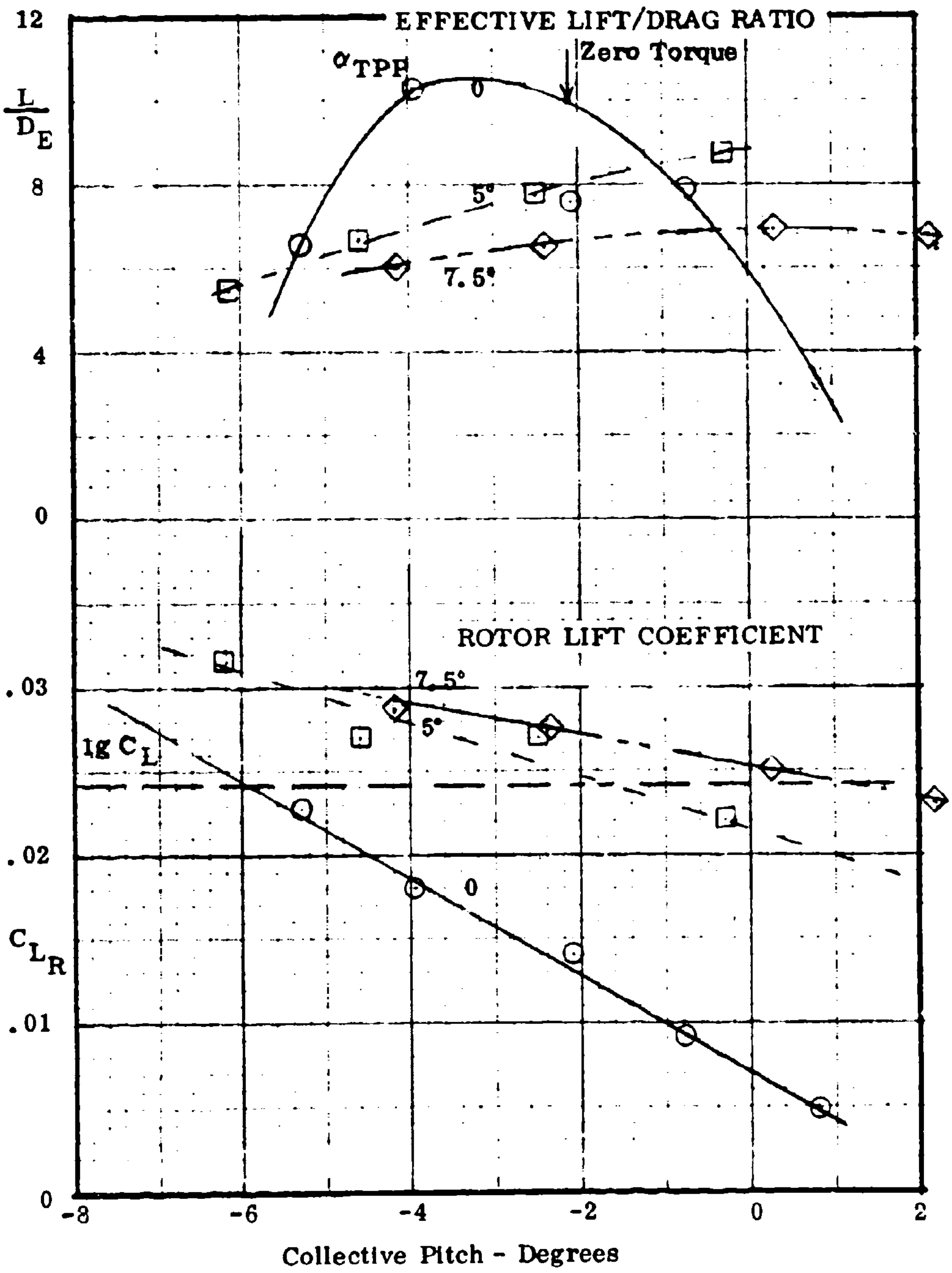
μ = 1.15, 833 r.p.m., 239 knots, $M_{1,90}$ = .66, ρ = .0021, run 54



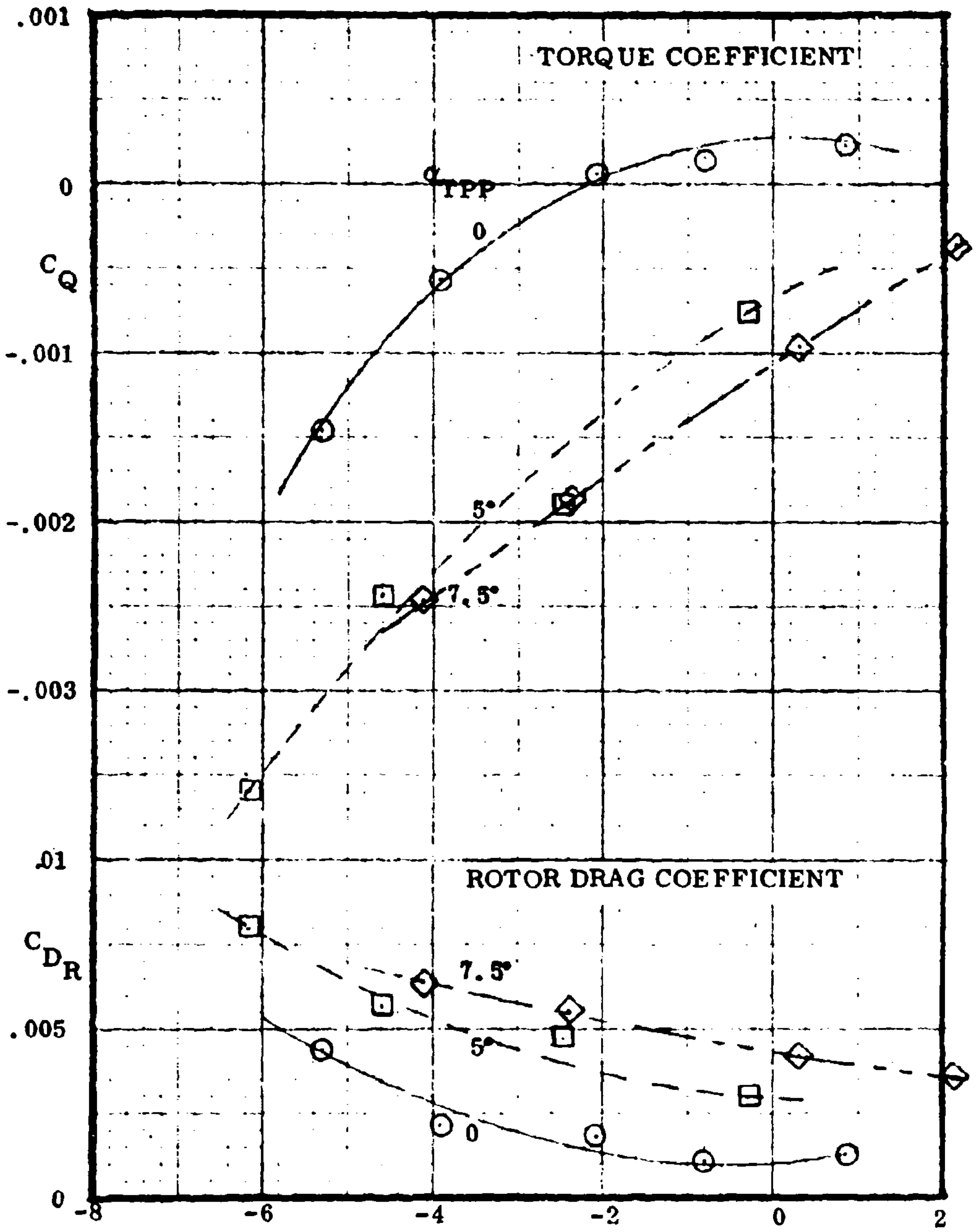
Collective Pitch - Degrees

MEASURED ROTOR PERFORMANCE

μ = 1.50, 660 r.p.m., 243 knots, $M_{1,90}$ = .59, ρ = .0021, run 53

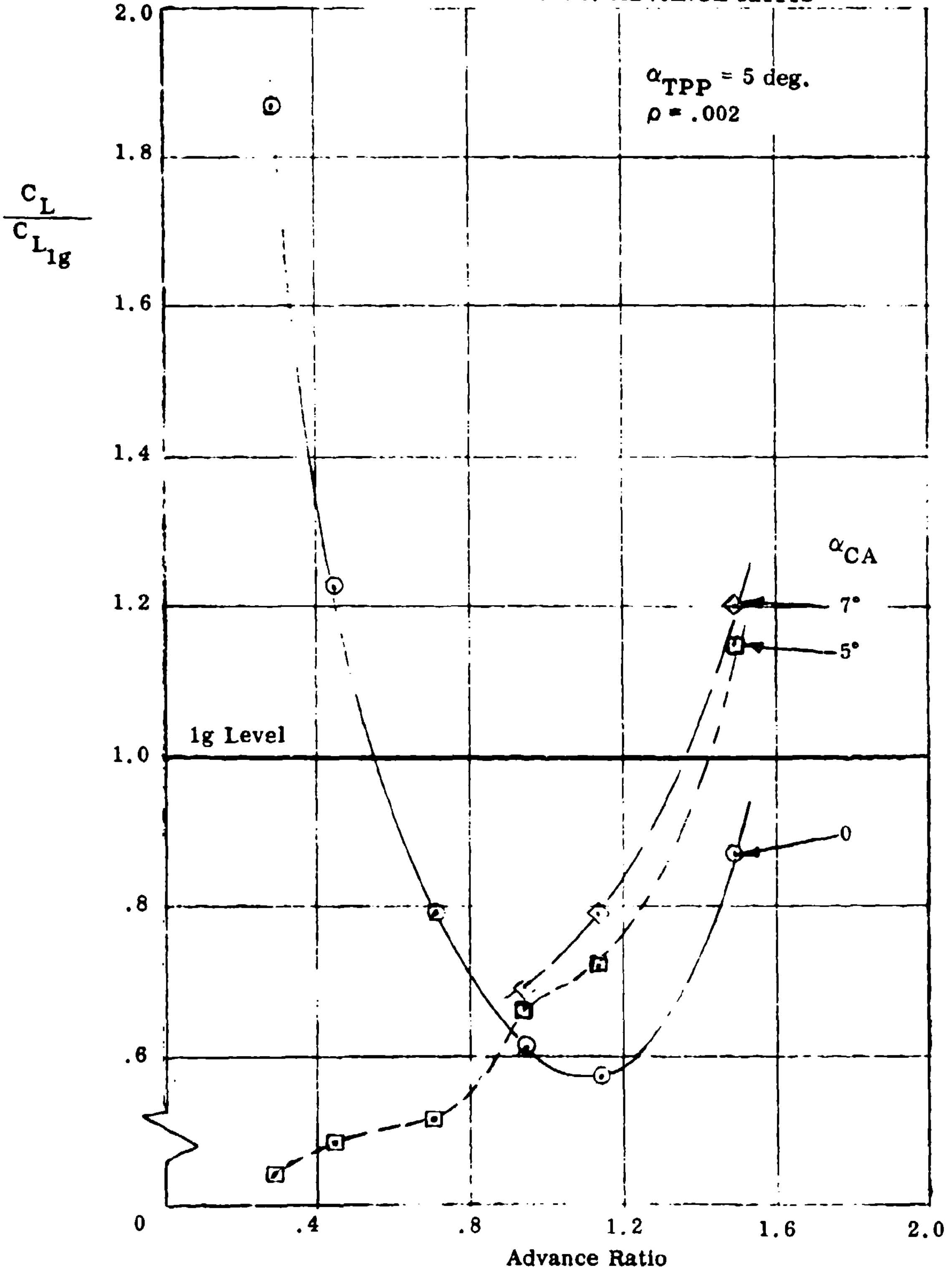


MEASURED ROTOR PERFORMANCE
μ = 1.50, 660 r.p.m., 243 knots, $M_{1,90}$ = .59, ρ = .0021, run 53



Collective Pitch - Degrees

ROTOR LIFT COEFFICIENT RATIO VS. ADVANCE RATIO



ROTOR LIFT COEFFICIENT RATIO VS. ADVANCE RATIO

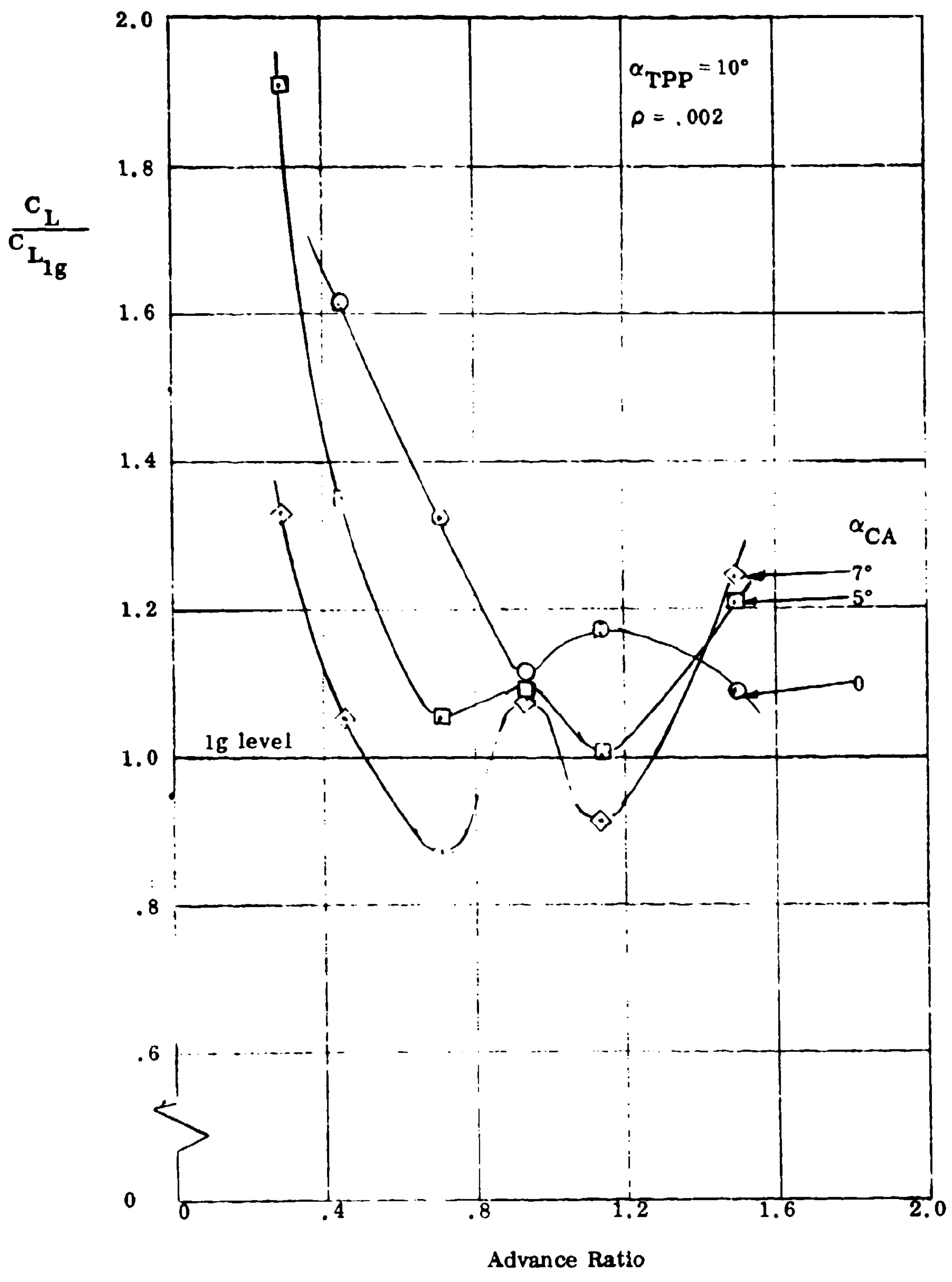


Figure 2.27

HC144R1070

MAXIMUM EFFECTIVE LIFT - DRAG RATIO MEASURED
VS ADVANCE RATIO

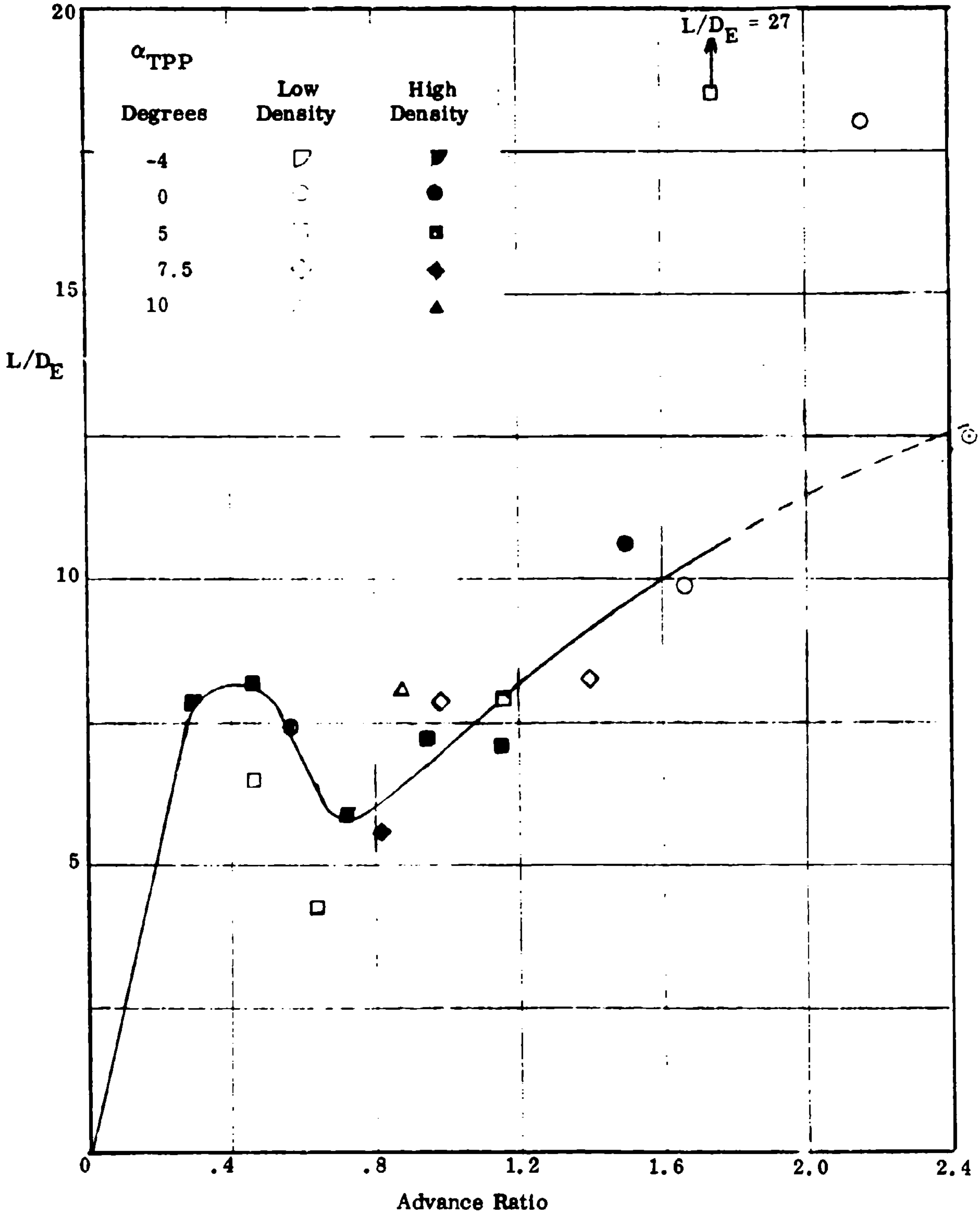
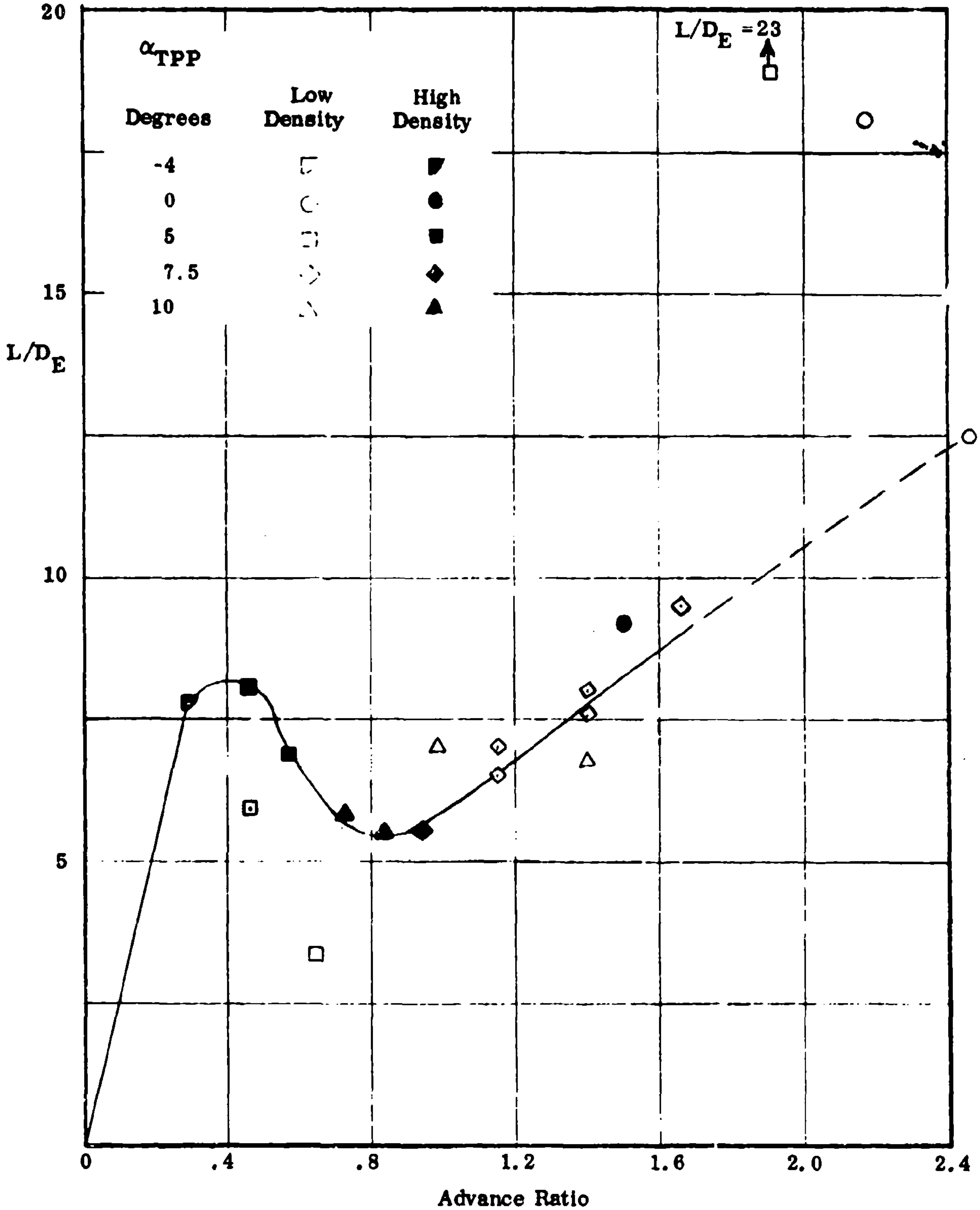


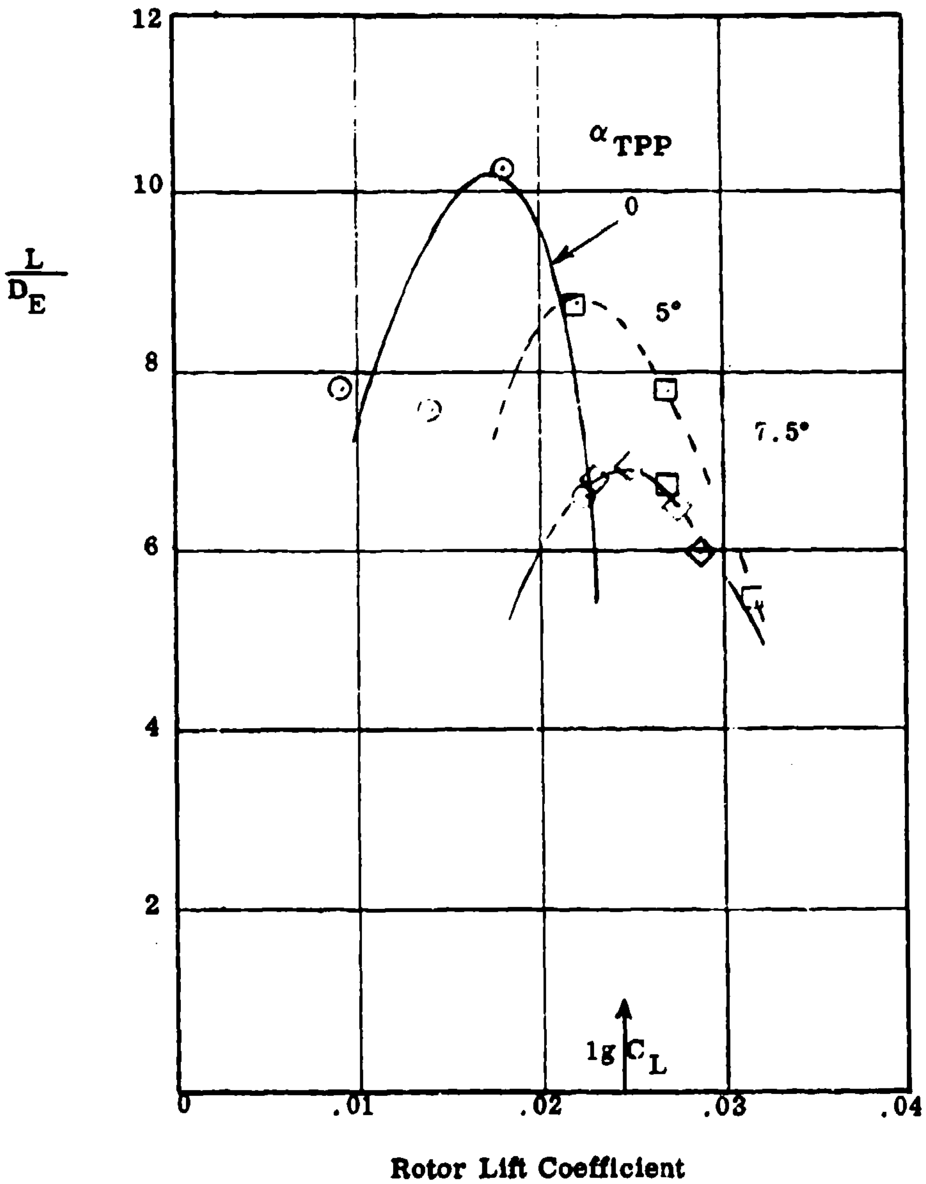
Figure 2.28

MEASURED EFFECTIVE LIFT - DRAG RATIO AT 8 LB. PER SQ. FT.
DISC LOADING VS ADVANCE RATIO

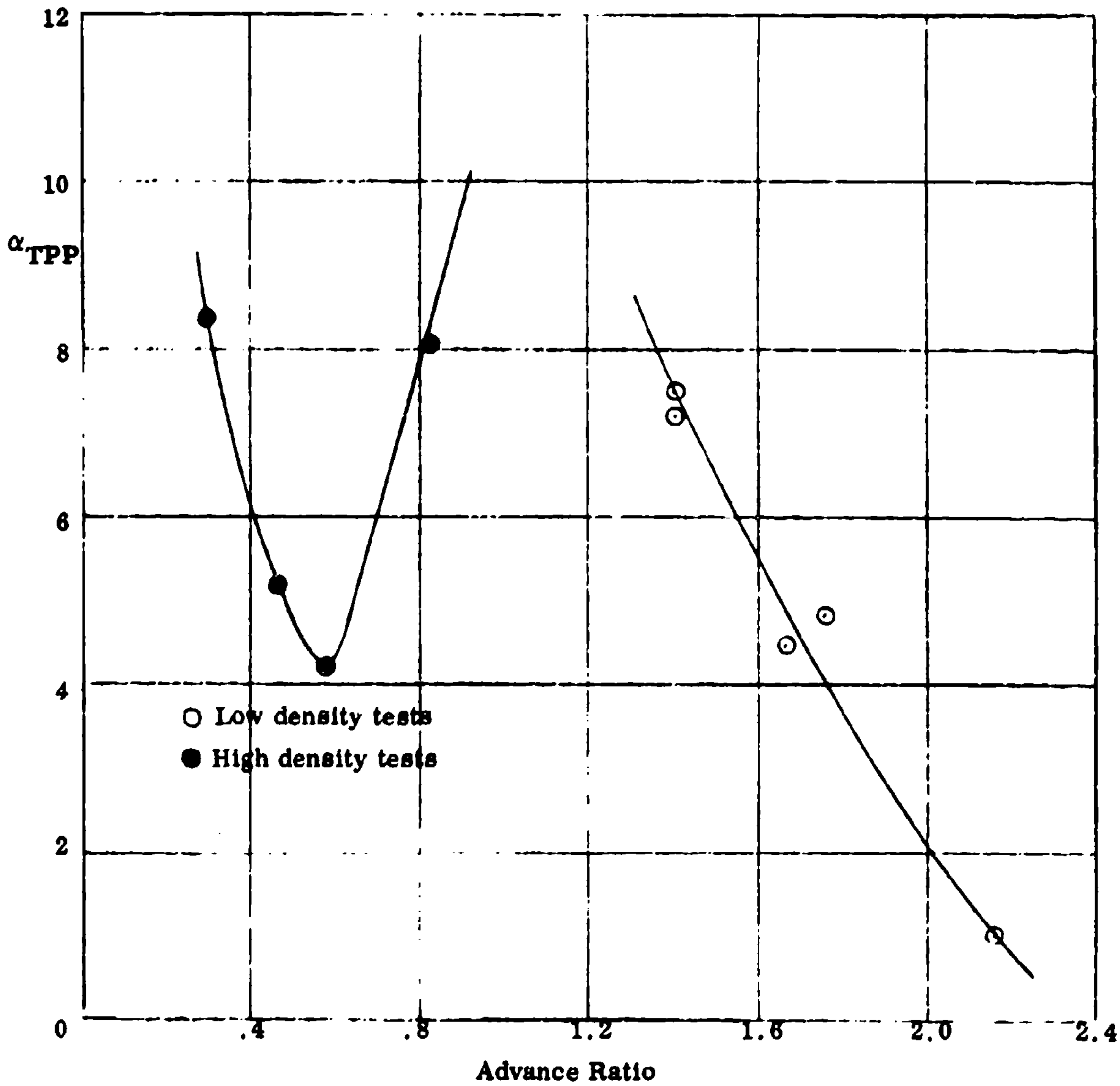


EFFECTIVE LIFT-DRAG RATIO VS
ROTOR LIFT COEFFICIENT

$\mu = 1.50$, 660 rpm, 243 knots, $M_{1,90} = .59$, $\rho = .002$, Run 53.



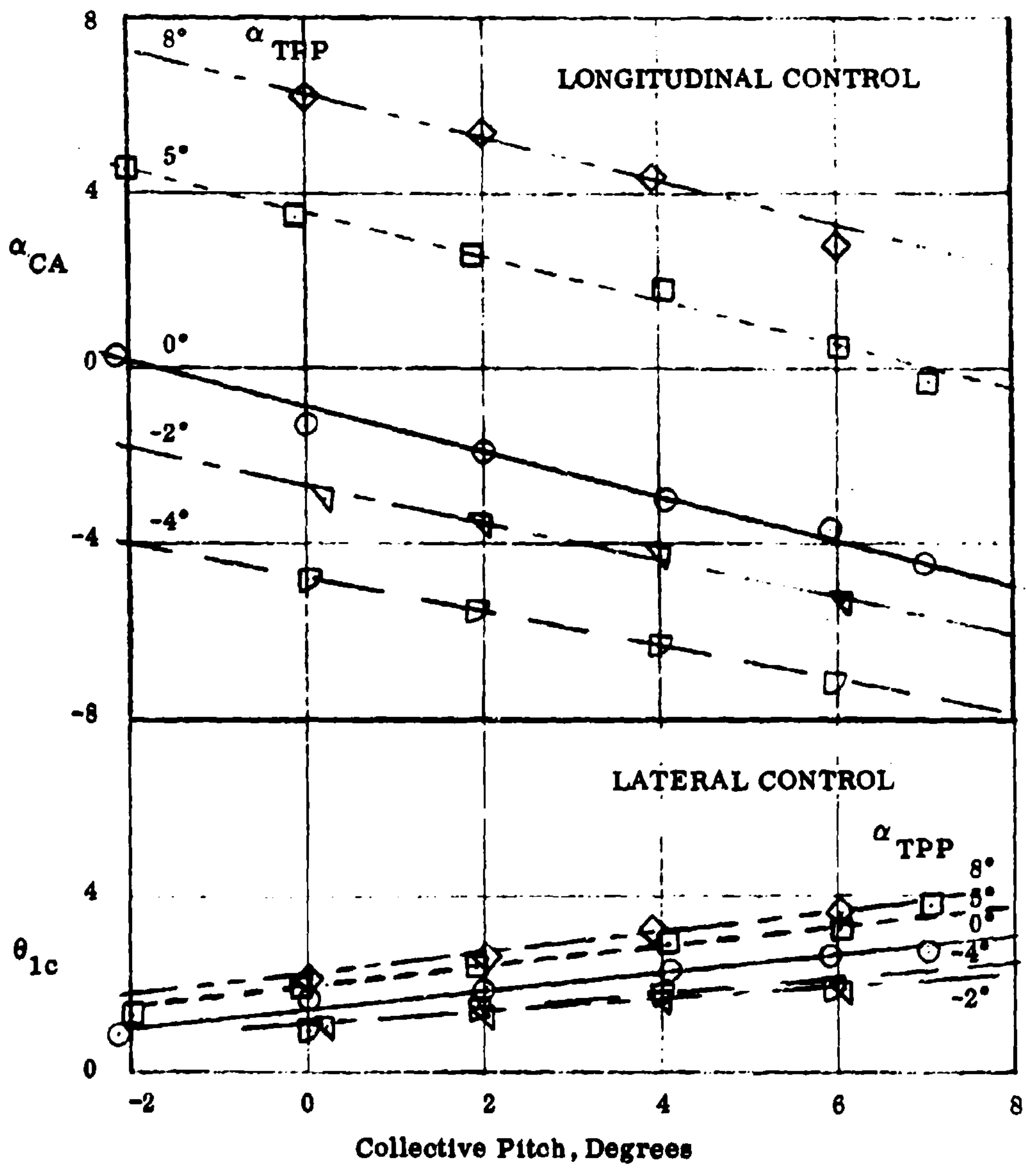
TIP PATH PLANE ANGLE FOR LEVEL FLIGHT
AND ZERO TORQUE VS ADVANCE RATIO



ROTOR CONTROL

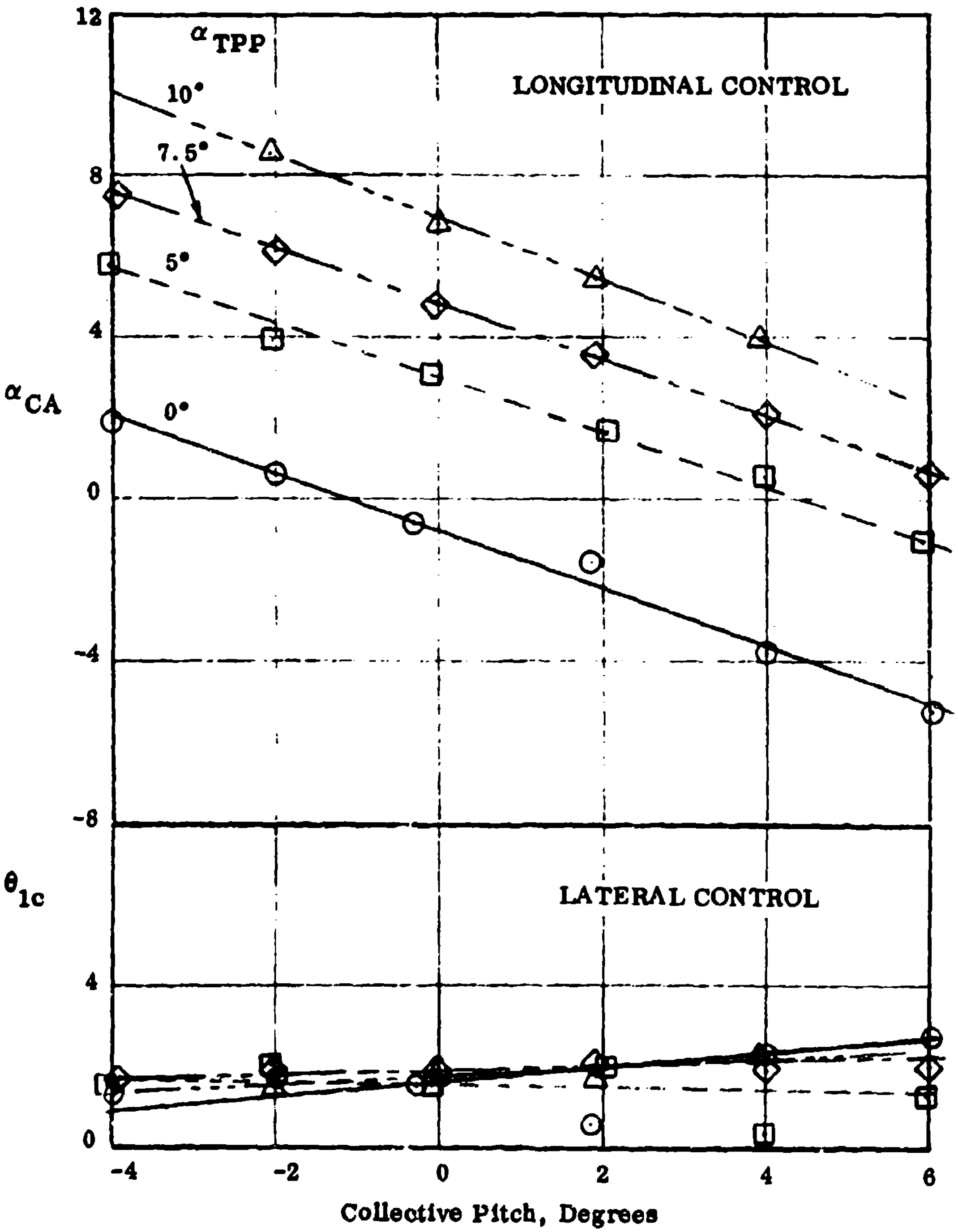
μ = .29, 1670 r.p.m., 121 knots, $M_{1,90}$ = .79, σ = .0023, run 50

(Rotor trimmed laterally and longitudinally)



ROTOR CONTROL

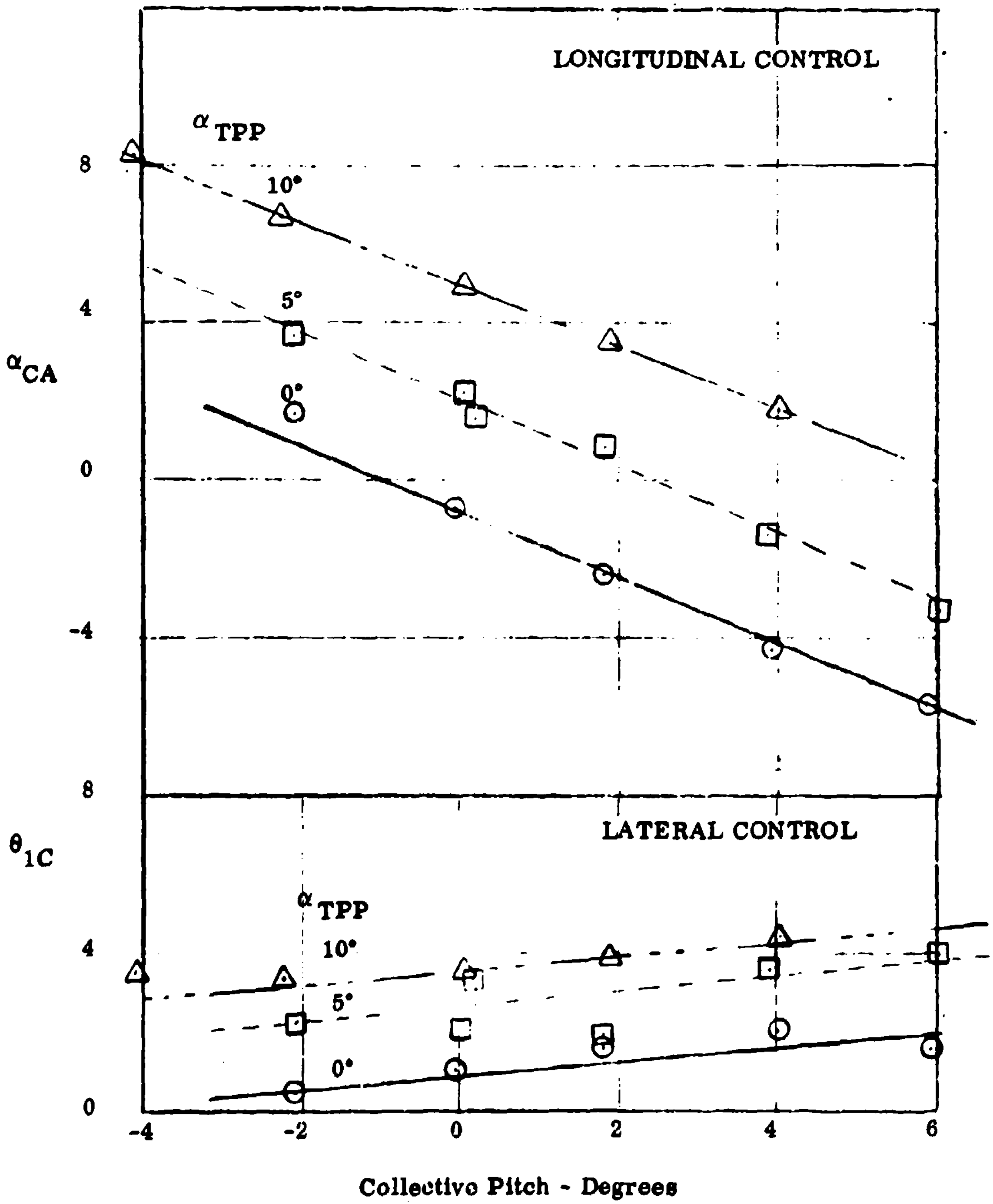
$\mu = .46$, 1670 r.p.m., 191 knots, $M_{1,90} = .89$, $\rho = .0022$, run 51



ROTOR CONTROL

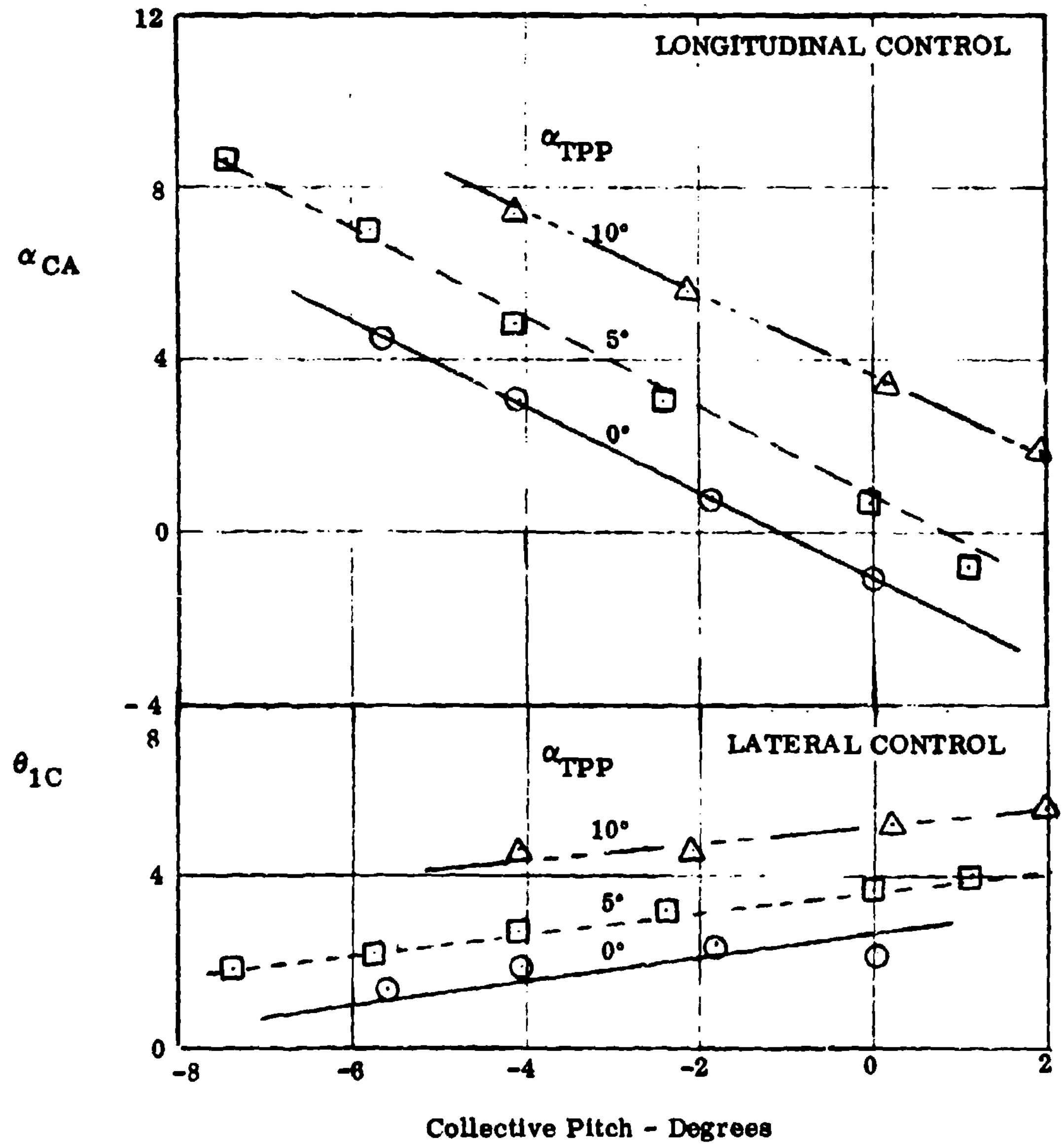
μ = .72, 1350 rpm, 243 knots, $M_{1,90}$ = .61, ρ = .0021, Run 57

(Rotor trimmed laterally and longitudinally)



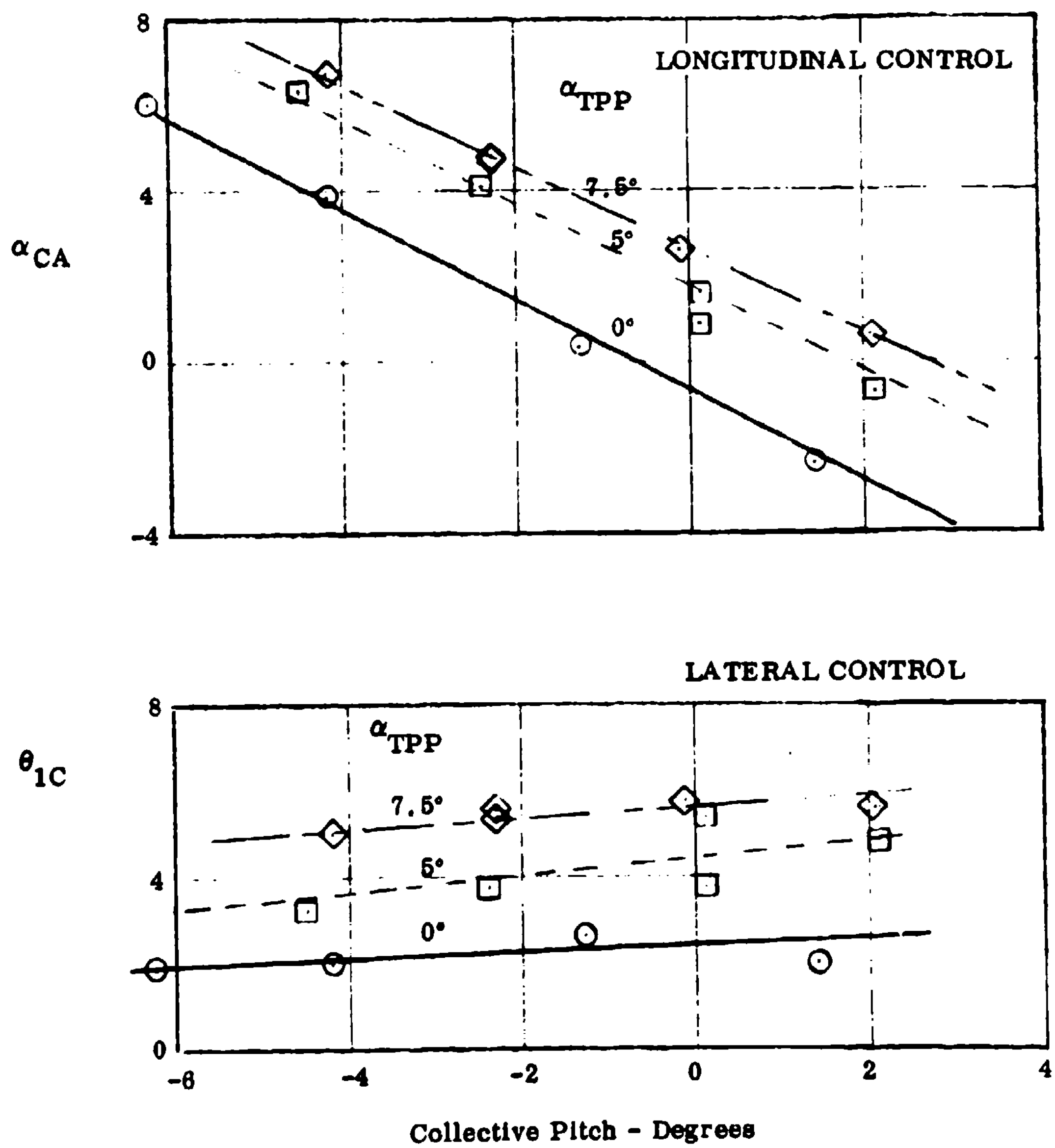
ROTOR CONTROL

$\mu = .94$, 1050 r.p.m., 243 knots, $M_{1.90} = .68$, $\rho = .0021$, Run 55



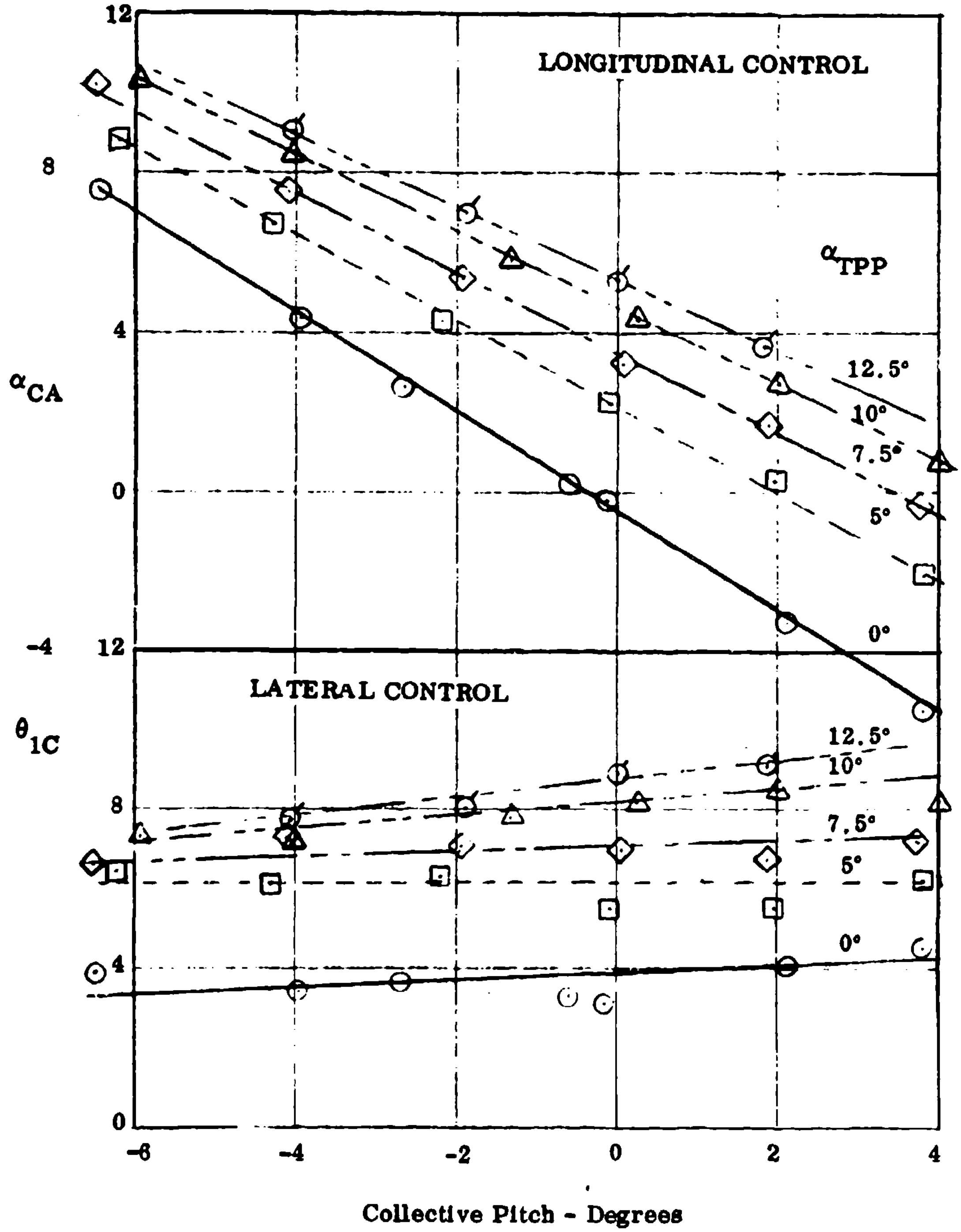
ROTOR CONTROL

$\mu = 1.15$, 833 r.p.m., 239 knots, $M_{1,90} = .66$, $\rho = .0021$, Run 54



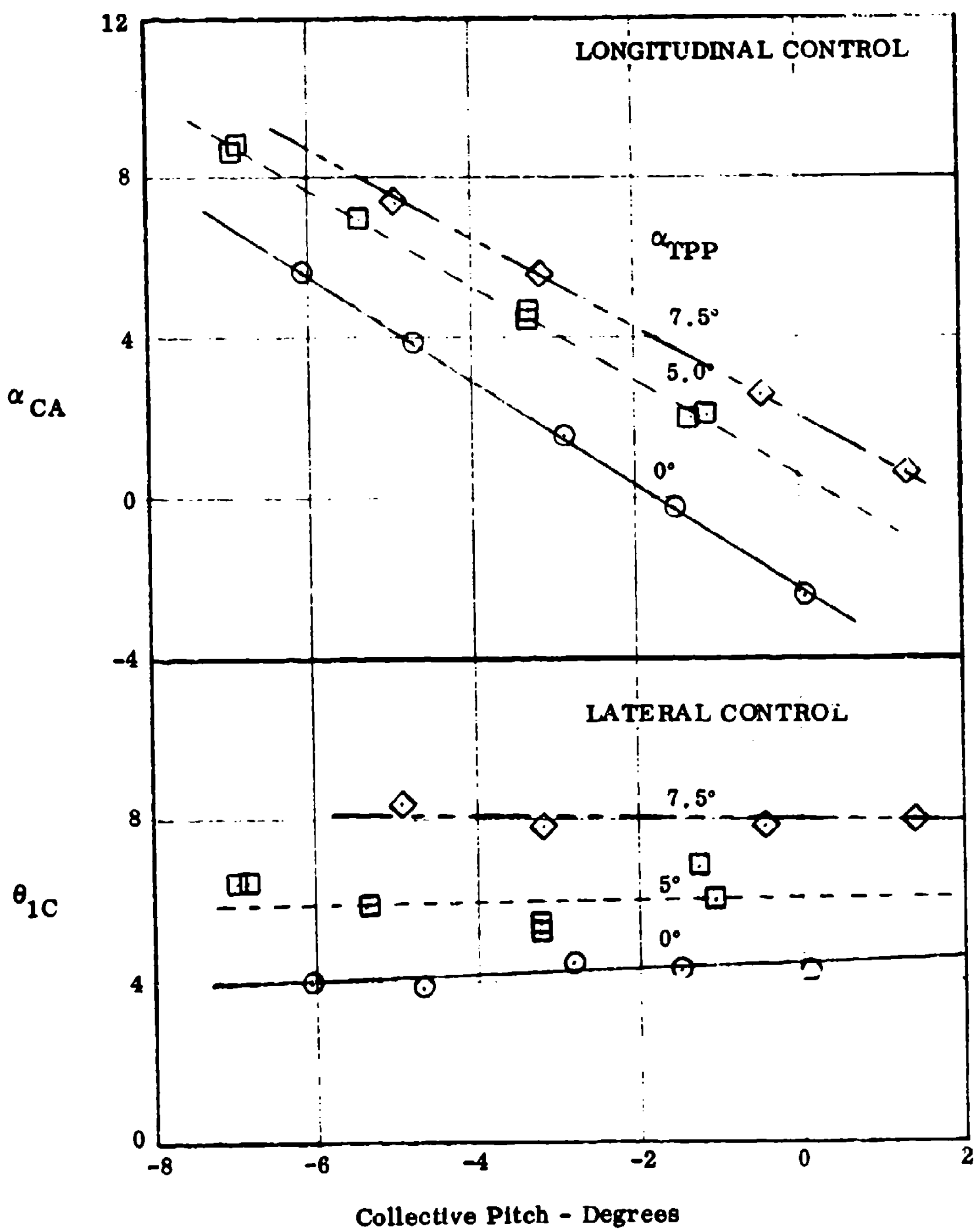
ROTOR CONTROL

$\mu = 1.45$, 820 r.p.m., 293 knots, $M_{1.90} = .75$, $\rho = .00205$, Run 60



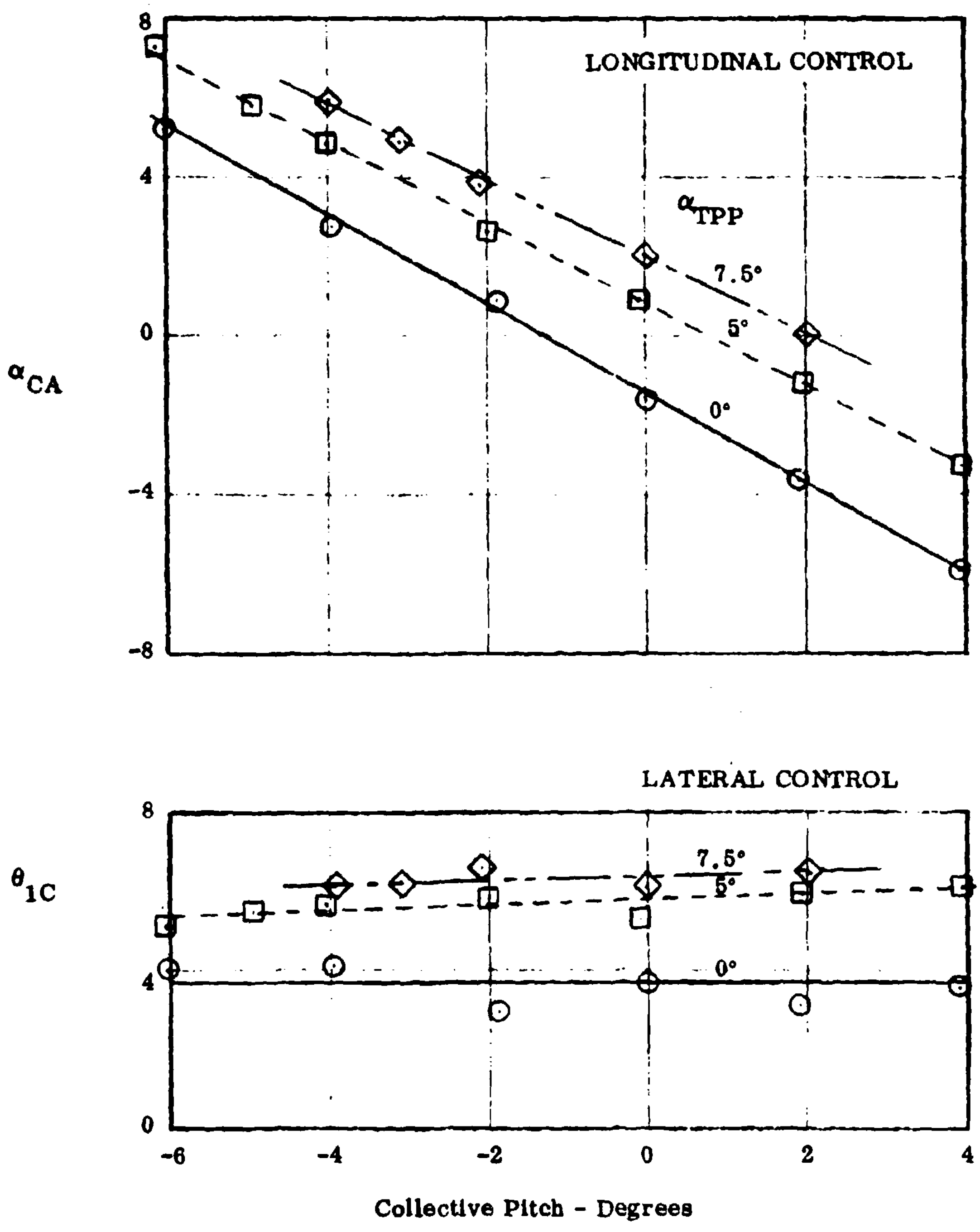
ROTOR CONTROL

$\mu = 1.50$, 660 r.p.m., 243 knots, $M_{1,00} = .59$, $\rho = .0021$, Run 53



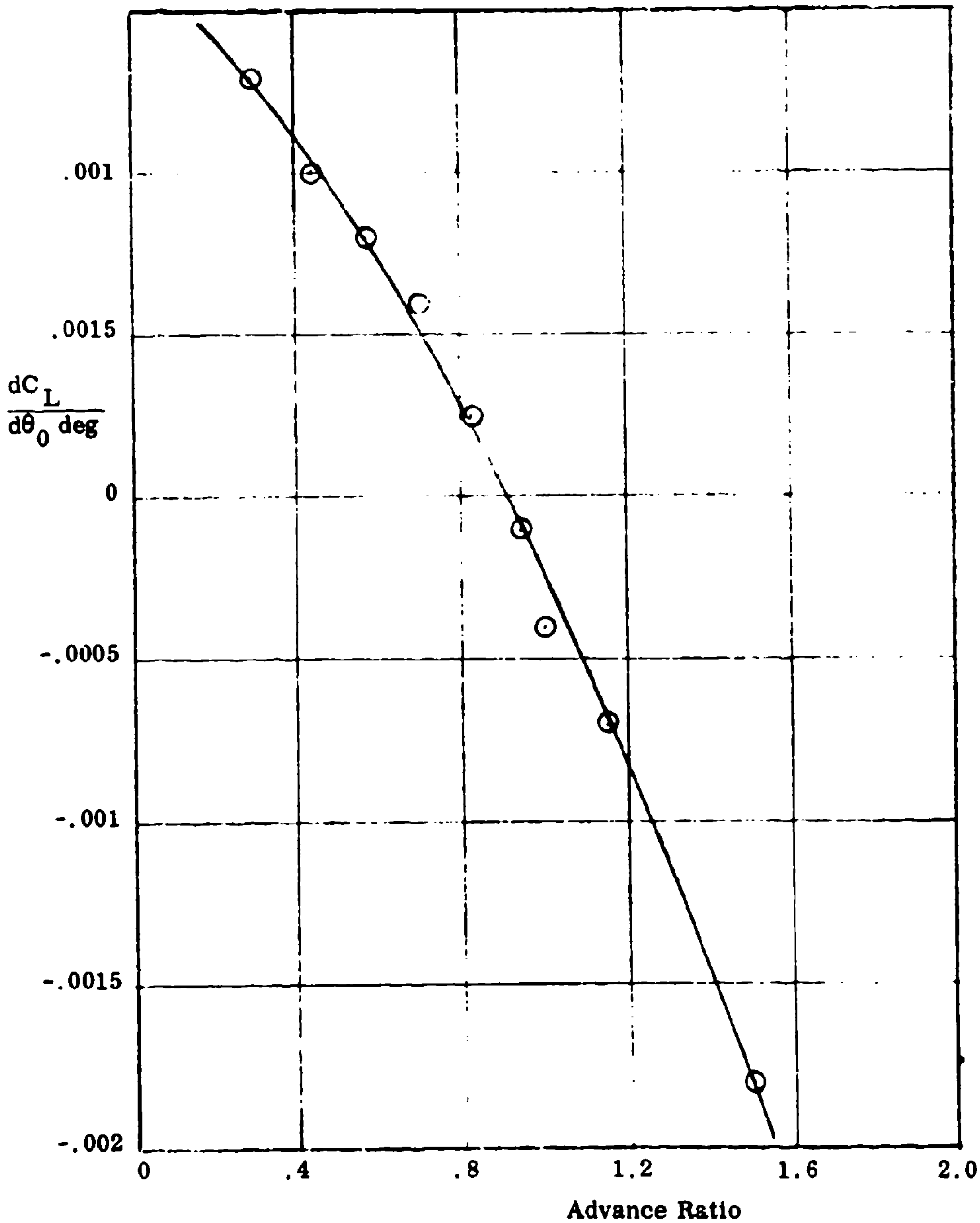
ROTOR CONTROL

$\mu = 1.40$, 970 r.p.m., 345 knots, $M_{1,90} = .86$, $\rho = .00084$, Run 46



COLLECTIVE CONTROL POWER AT 5 DEG
TIP PATH PLANE

(Rotor Trimmed Laterally and Longitudinally)
ρ = .002 slugs/ft^3



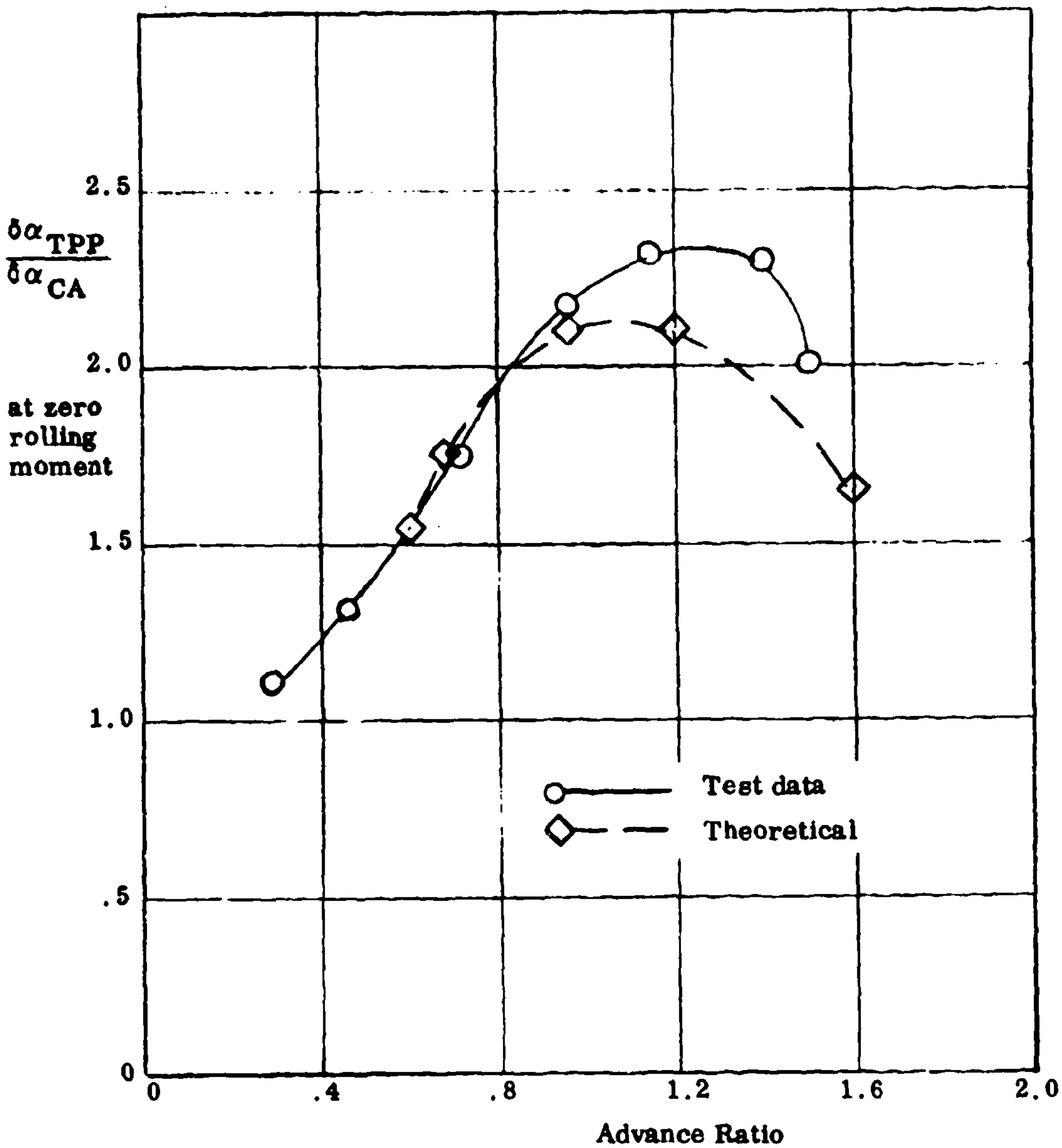
FAIRCHILD
REPUBLIC DIVISION

Figure 3.10

ROTOR TIP PATH PLANE DERIVATIVE WITH RESPECT TO CONTROL AXIS ANGLE AT CONSTANT ROLLING MOMENT

(Lateral Control Adjusted to Keep Rolling Moment Zero During Variations in Control Axis Angle)

$\rho = .0020$ slugs/ft^3



THEORETICAL PHASE ANGLE OF FLAPPING RESPONSE
TO ONE-PER-REV CYCLIC INPUT IN HOVER

ρ = .002378 slugs/ft^3

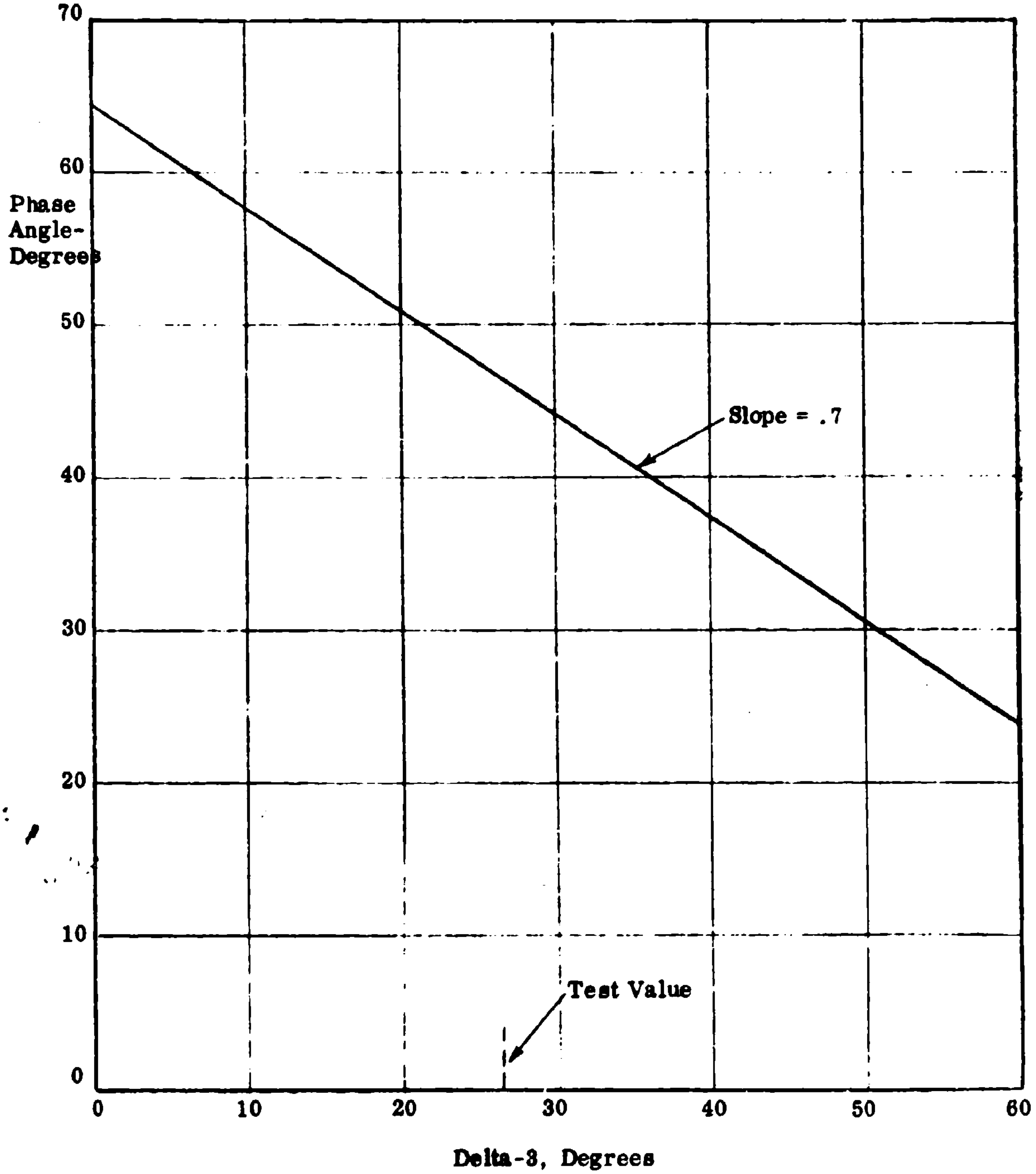


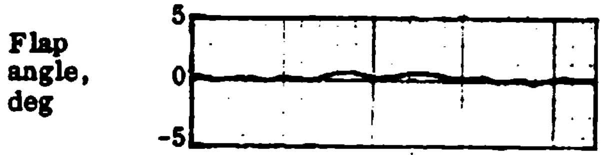
Figure 3.12

ROTOR FLAPPING

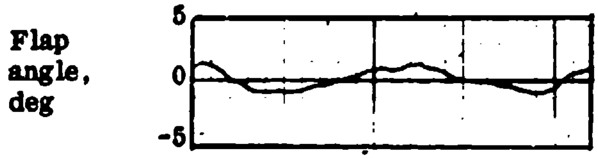
Trimmed 1g conditions, ρ = .002

Traces shown are one rotor revolution from 0° to 360° azimuth

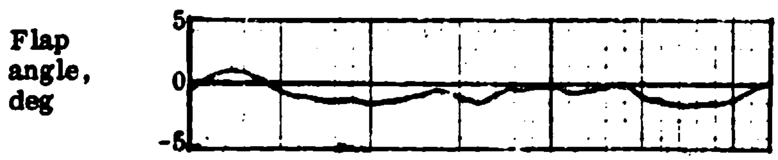
μ = .29 C_L = .0081 Run 50



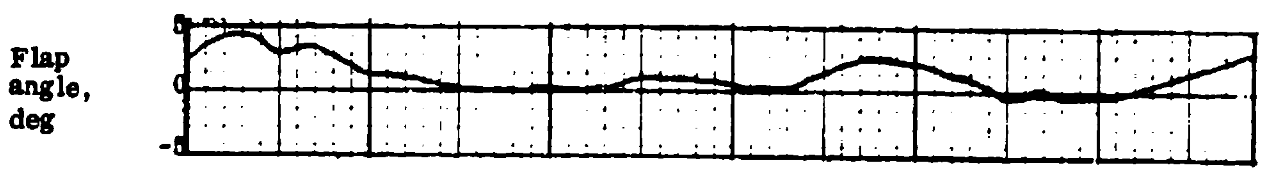
μ = .46 C_L = .0079 Run 51



μ = .82 C_L = .0116 Run 56

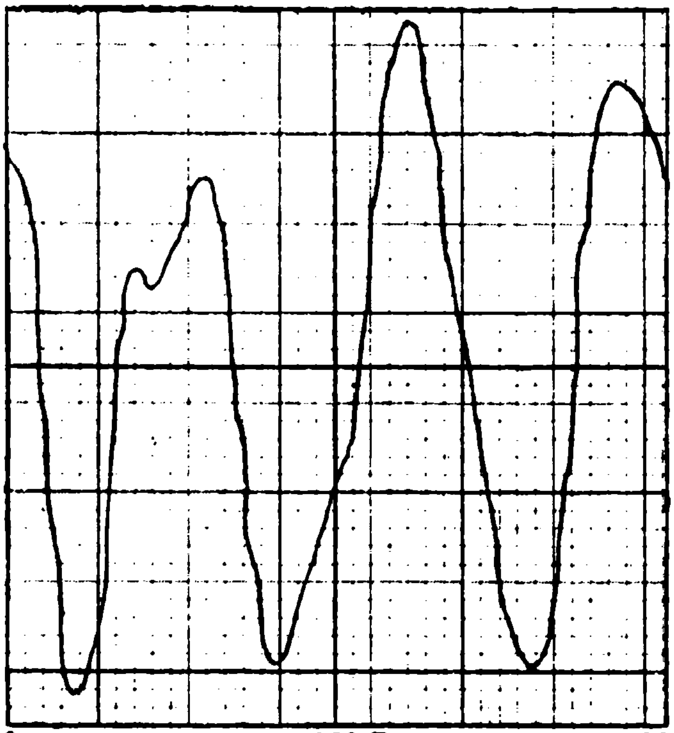


μ = 1.5 C_L = .029 Run 53

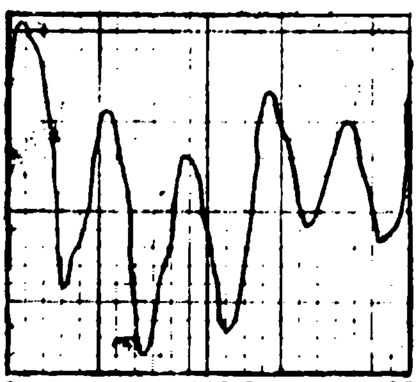


TYPICAL TRACES OF FLAPWISE VIBRATORY MOMENTS
NEAR RESONANCES - OUTBOARD STATION ~ .71R

Resonance of 2nd Flap Mode at 3/Rev



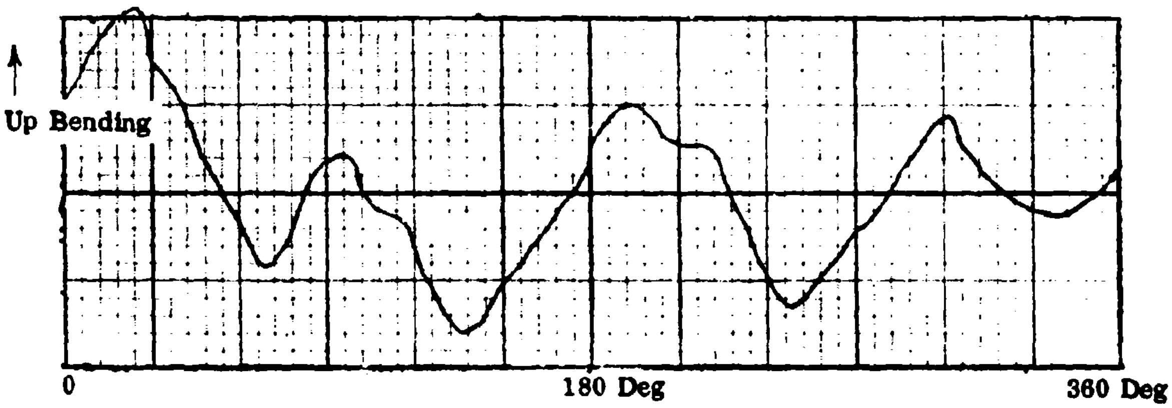
Resonance of 3rd Flap Mode at 5/Rev



TYPICAL TRACES OF FLAPWISE VIBRATORY MOMENTS
NEAR RESONANCES - OUTBOARD STATION ~ .71R

Resonance of 2nd Flap Mode at 4/Rev

667 rpm, Run 53, Correlate 661



Resonance of 3rd Flap Mode at 10/Rev

635 rpm, Run 44, Correlate 449

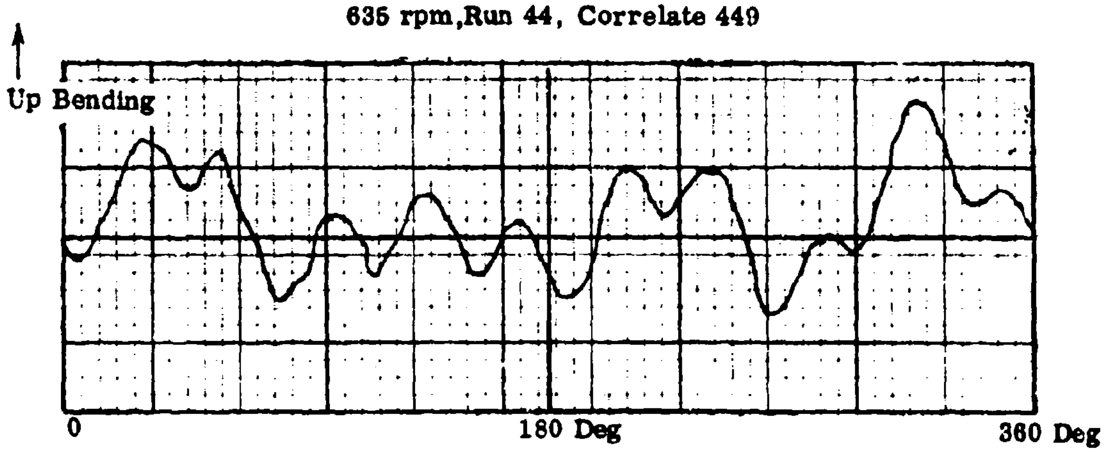


Figure 4.2

MEASURED VIBRATORY FLAPWISE BENDING MOMENTS
AT CRITICAL STATIONS

(One half peak-to-peak values)

1g Lift coefficients, 830 rpm, ρ = .0008 slugs/ft^3

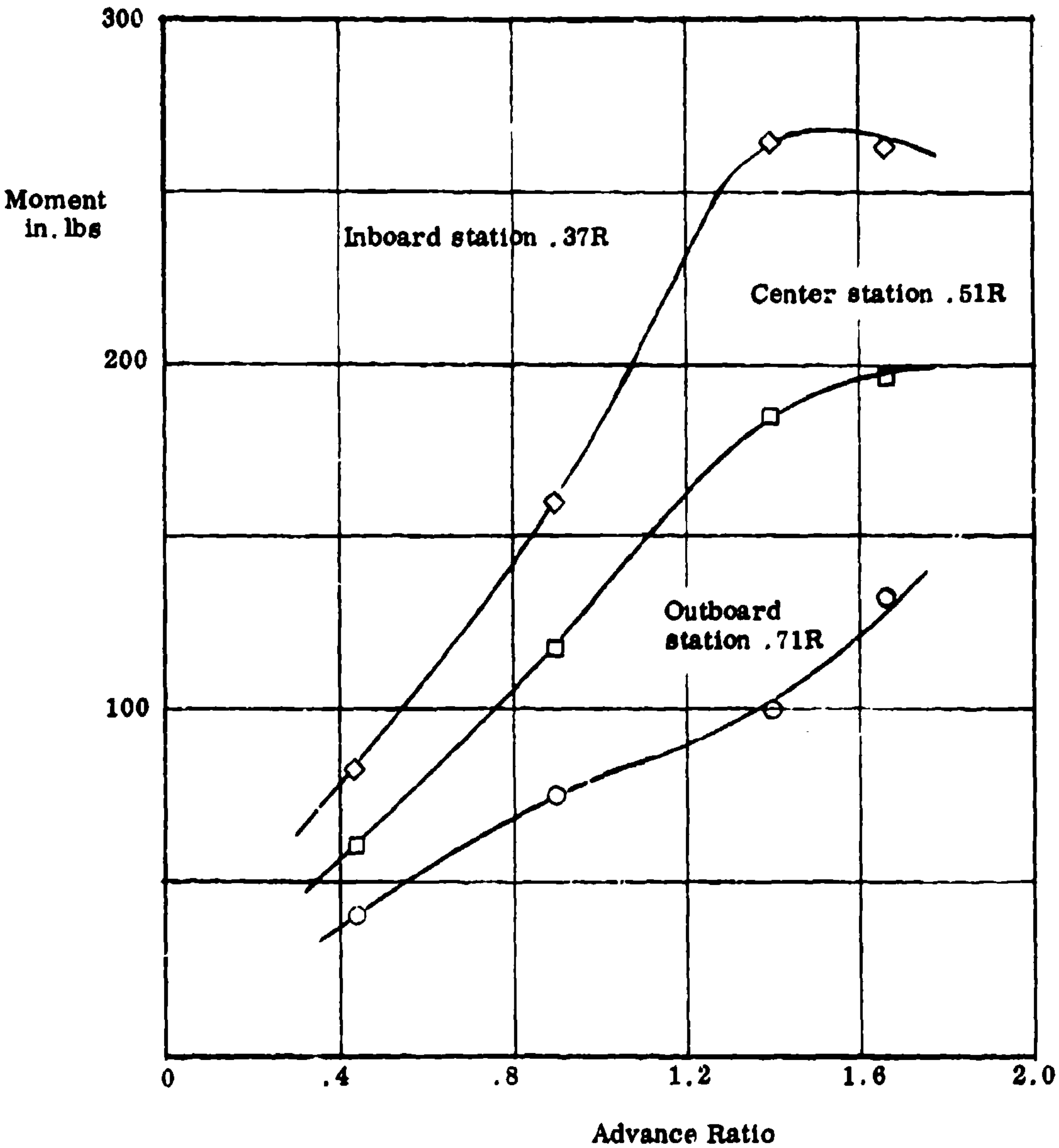
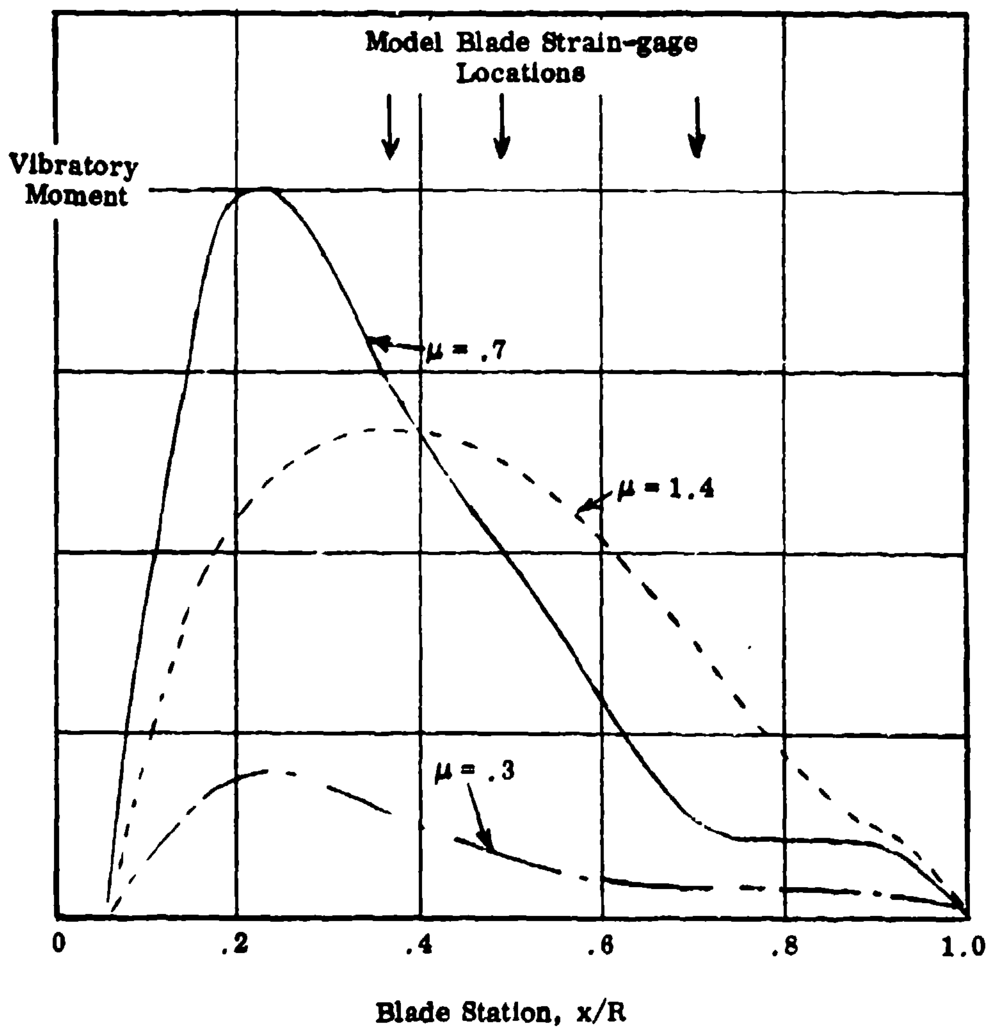


Figure 4.3

TYPICAL THEORETICAL SPANWISE DISTRIBUTIONS OF VIBRATORY FLAPWISE BENDING MOMENT

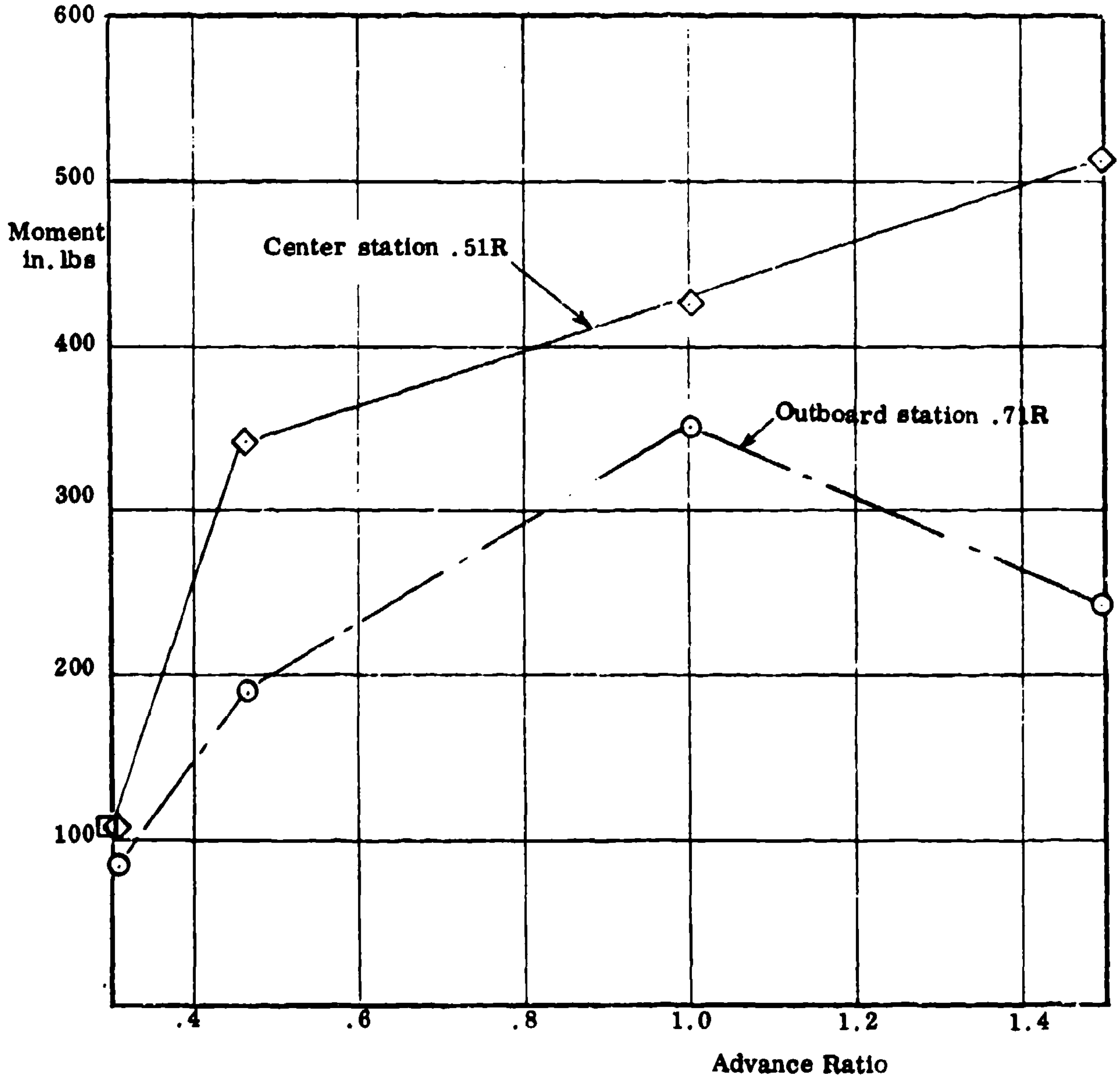
At 1g Lift Coefficients. Non-resonant r.p.m.



MEASURED VIBRATORY FLAPWISE BENDING MOMENTS AT SCHEDULED FLIGHT CONDITIONS

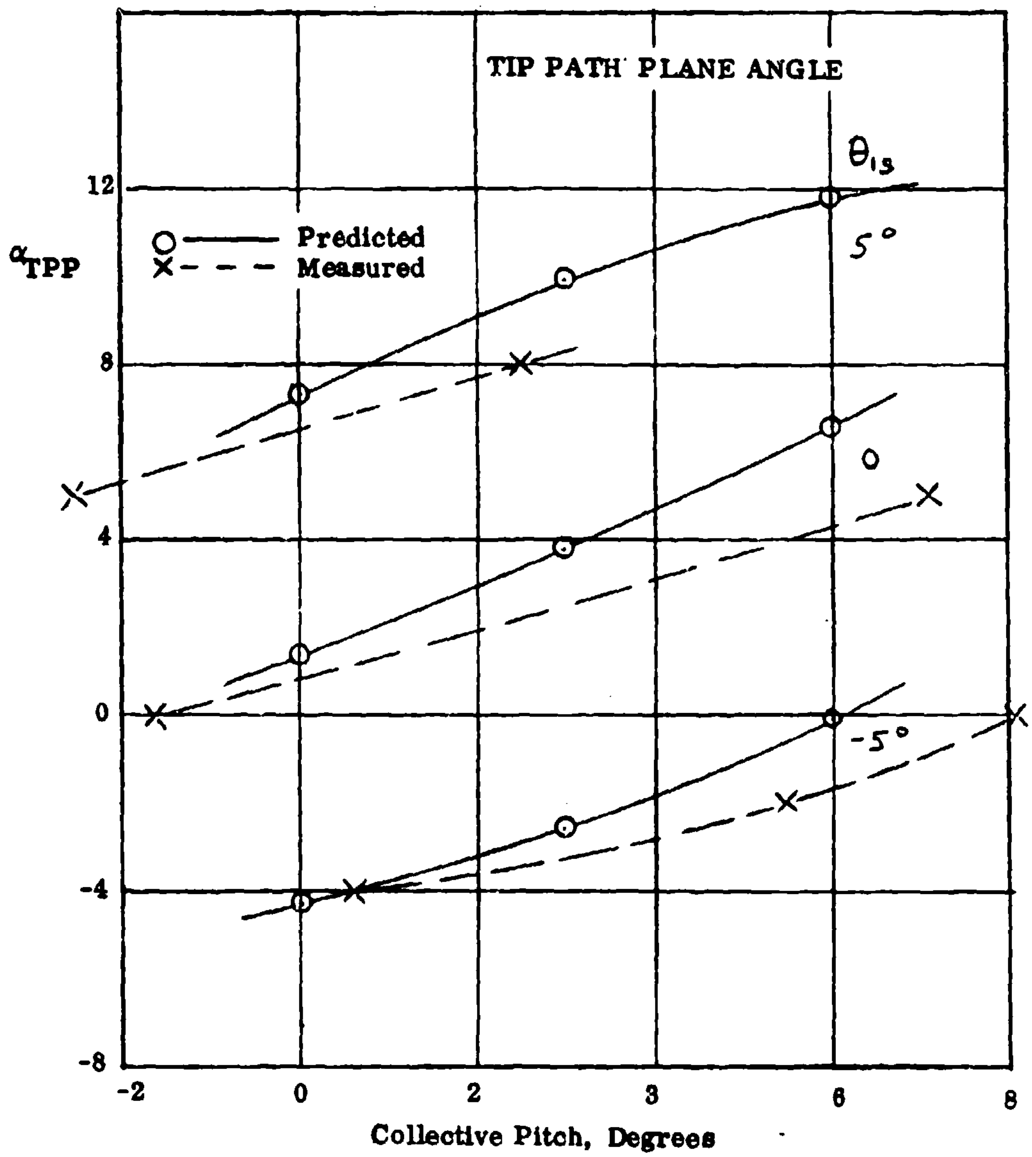
(One half peak-to-peak values)

$\rho = .002$ slugs/ft^3



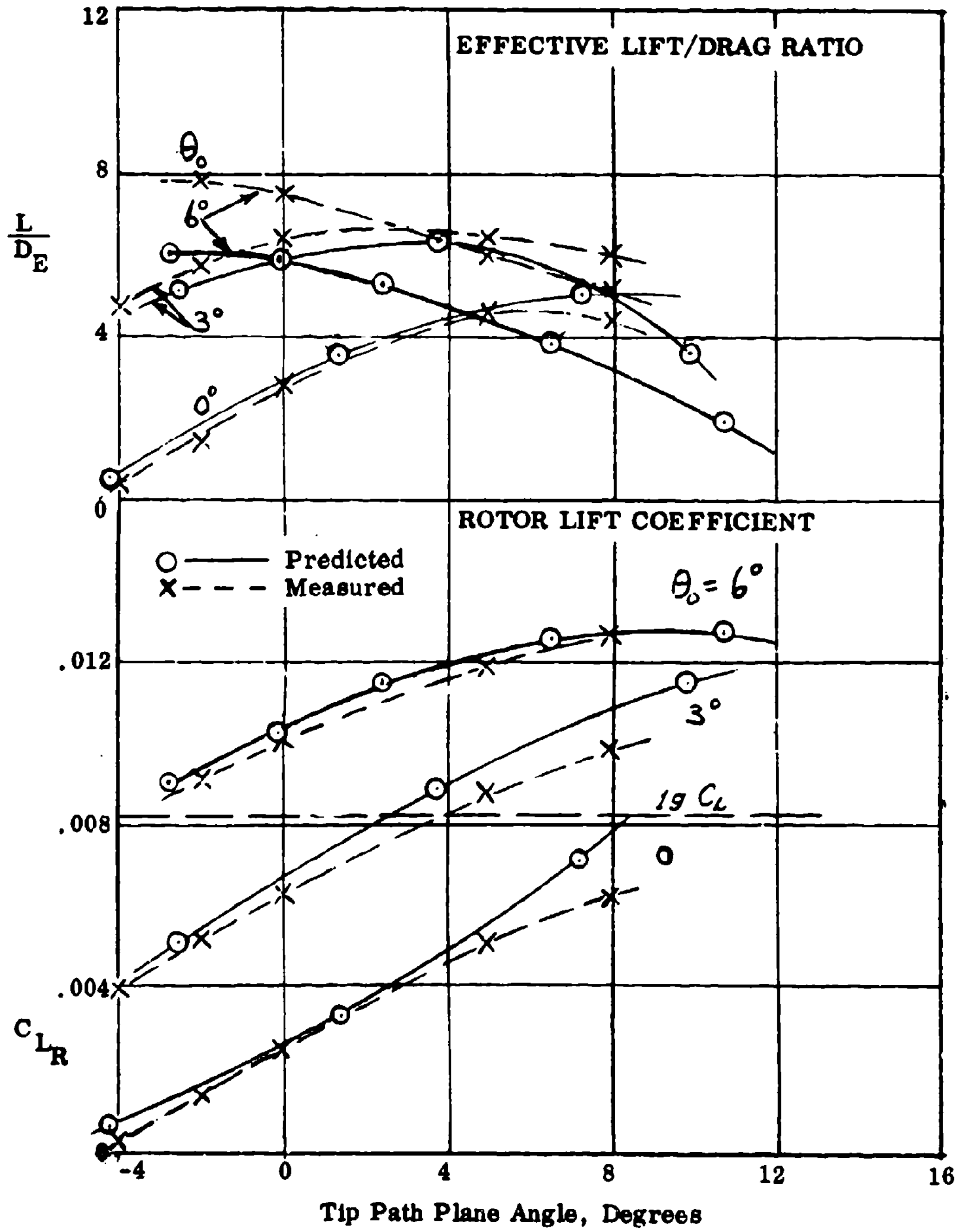
COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE

$\mu = .29$, 1670 r.p.m, 121 knots, $M_{1,\ 90} = .79$, $\rho = .0023$, run 50



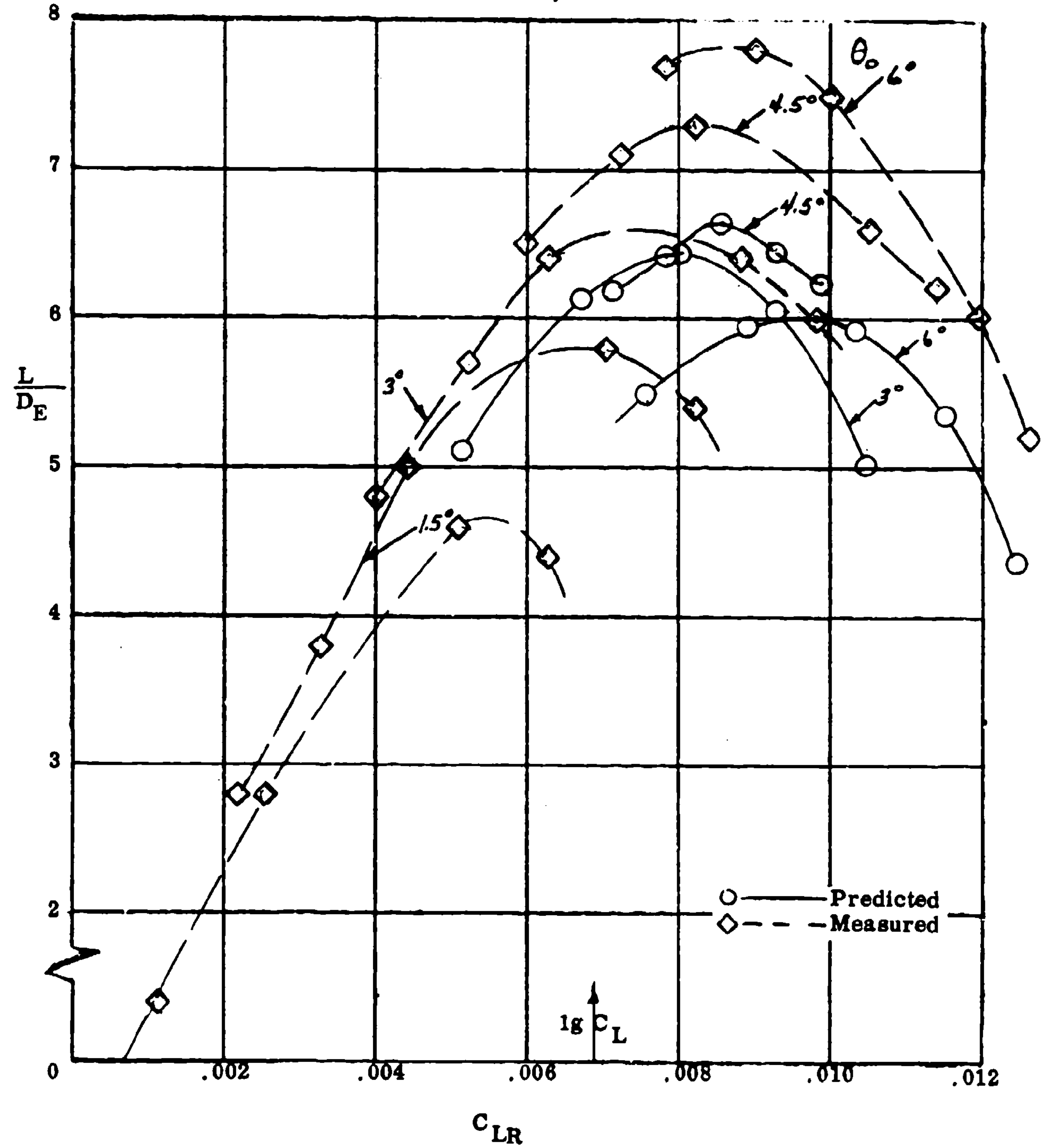
COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE

$\mu = .29$, 1670 r.p.m., 121 Knots, $M_{1,\,90} = .79$, $\rho = .0023$, run 50



COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE

μ = .29, 1670 r.p.m., 121 Knots, $M_{1,\ 90}$ = .79, ρ = .0023, run 50



COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE
$\mu = .46$, 1670 r.p.m., 191 knots, $M_{1,90} = .89$, $\rho = .0022$, run 51

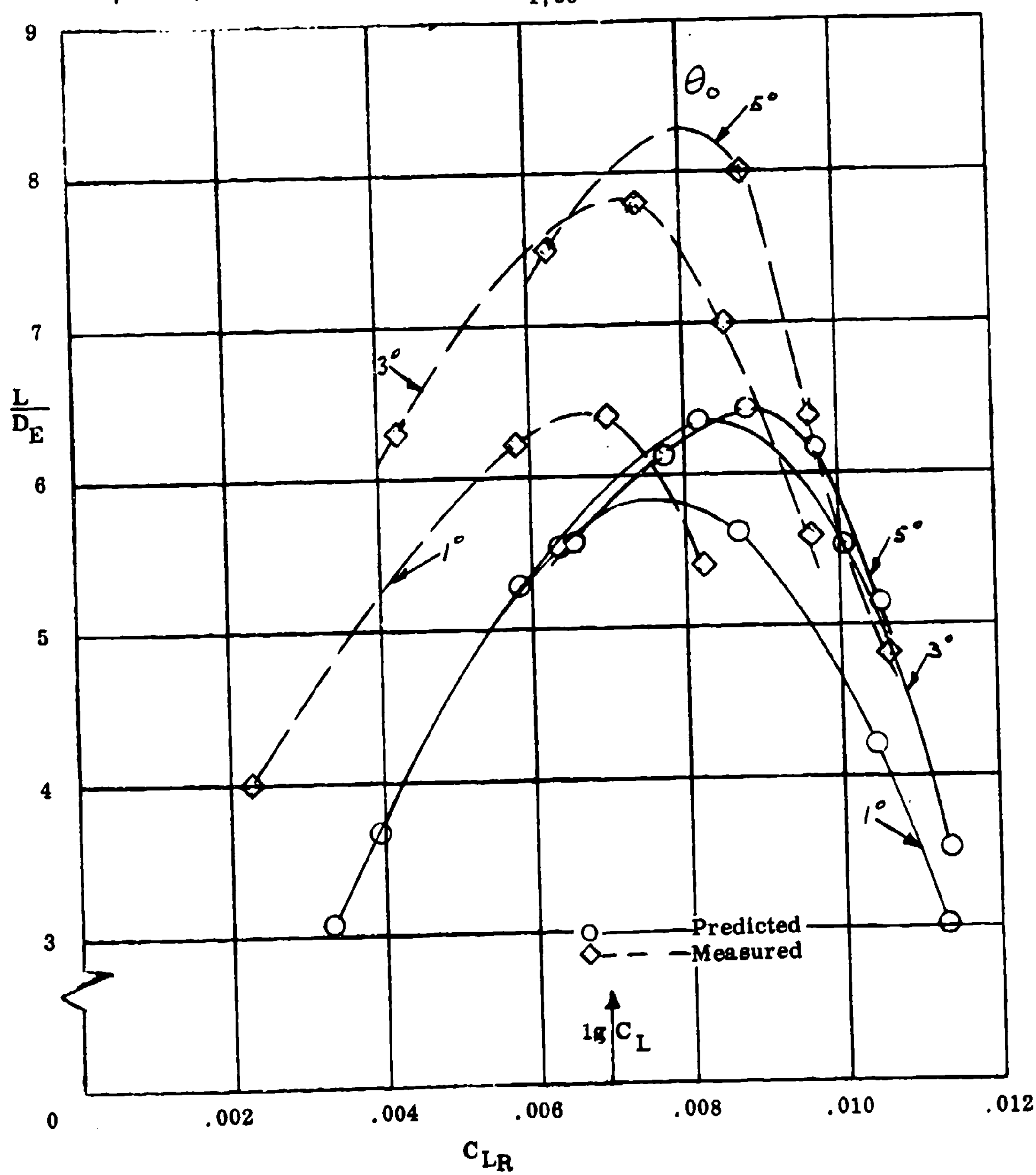
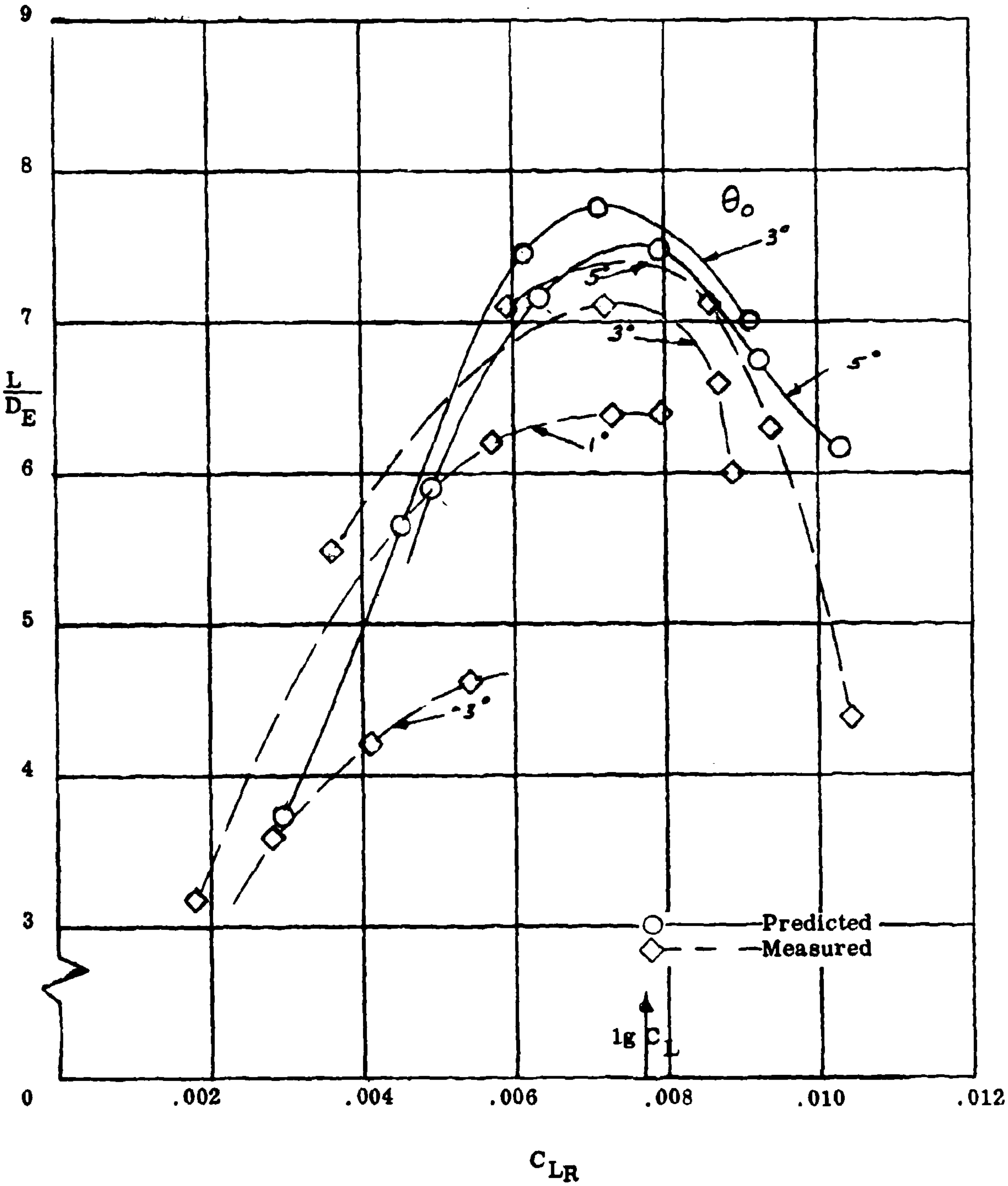


Figure 5.4

COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE
$\mu = .57$, 1330 r.p.m., 192 knots, $M_{1,\ 90} = .76$, $\rho = .0022$, run 52



COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE
$\mu = .72$, 1350 r.p.m., 243 knots, $M_{1,\ 90} = .61$, $\rho = .0021$, run 57

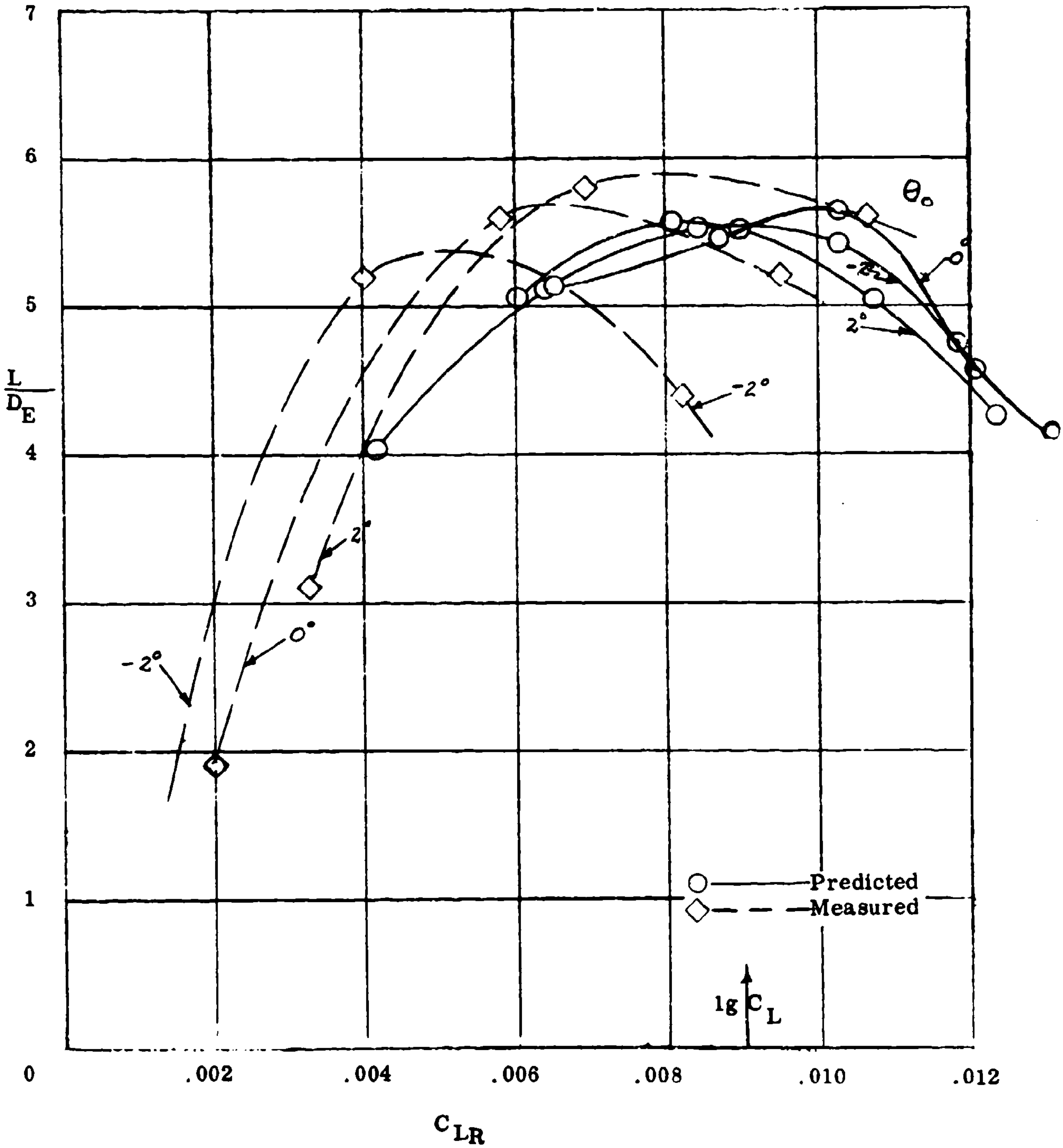
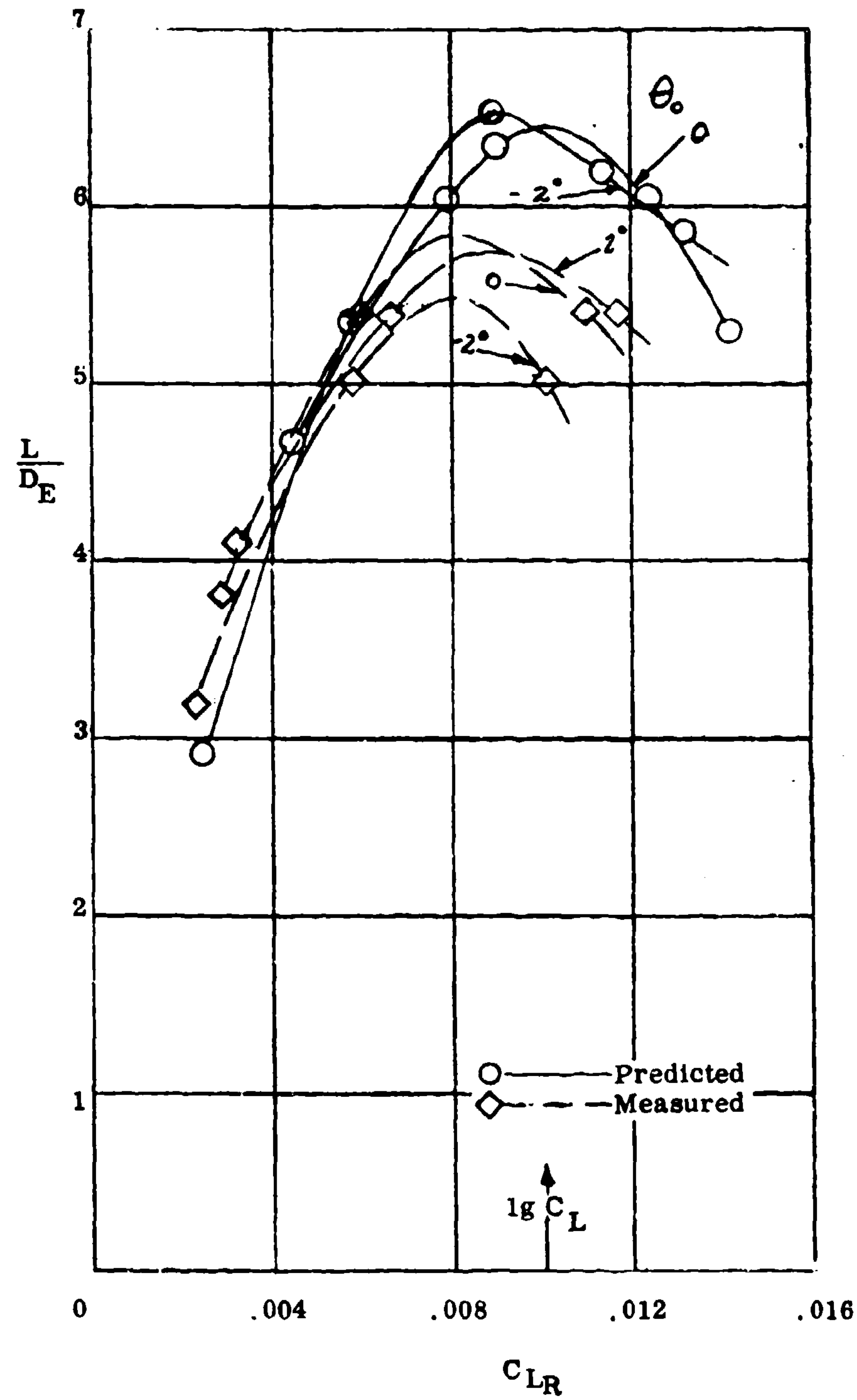


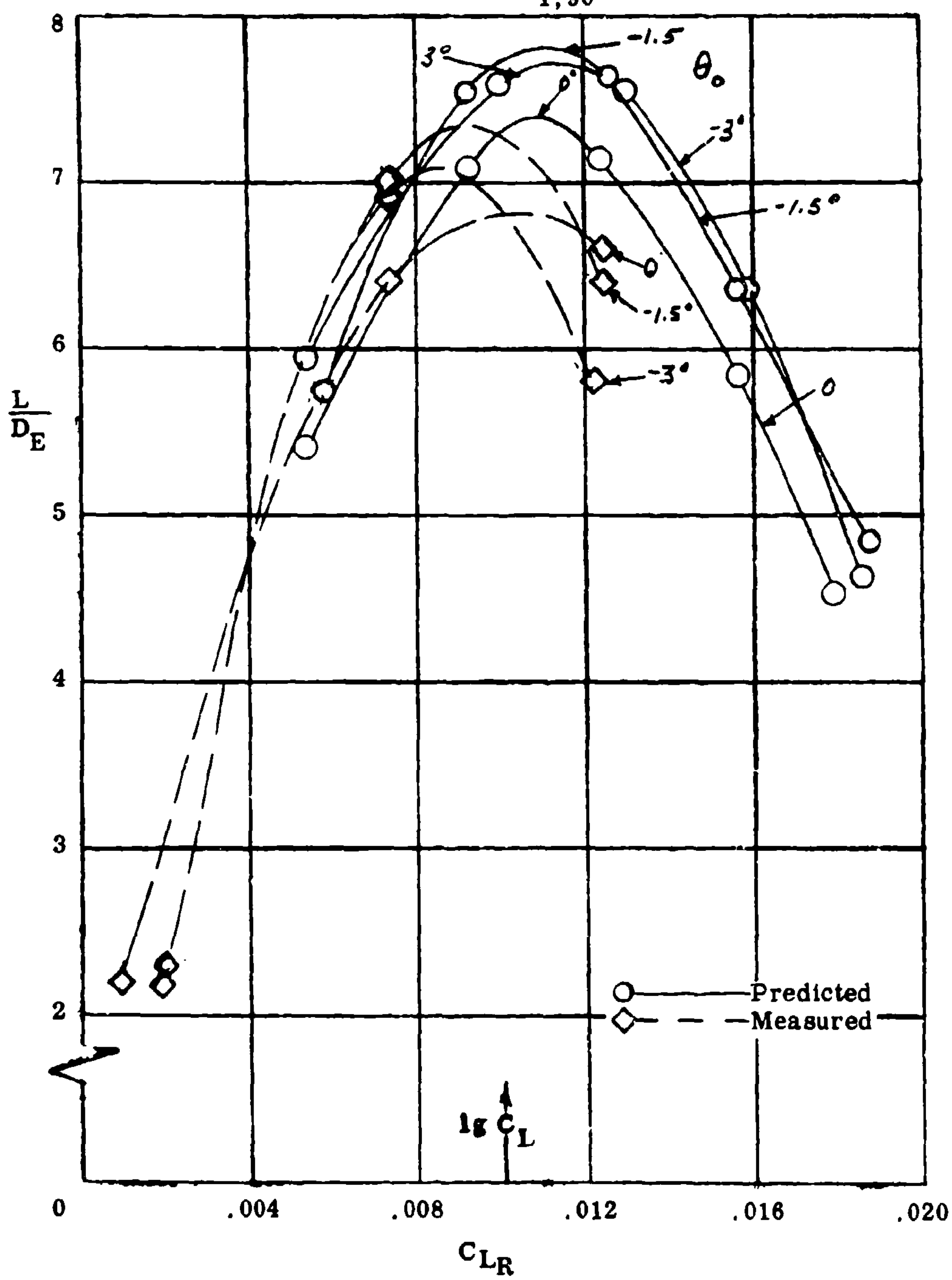
Figure 5.6

COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE

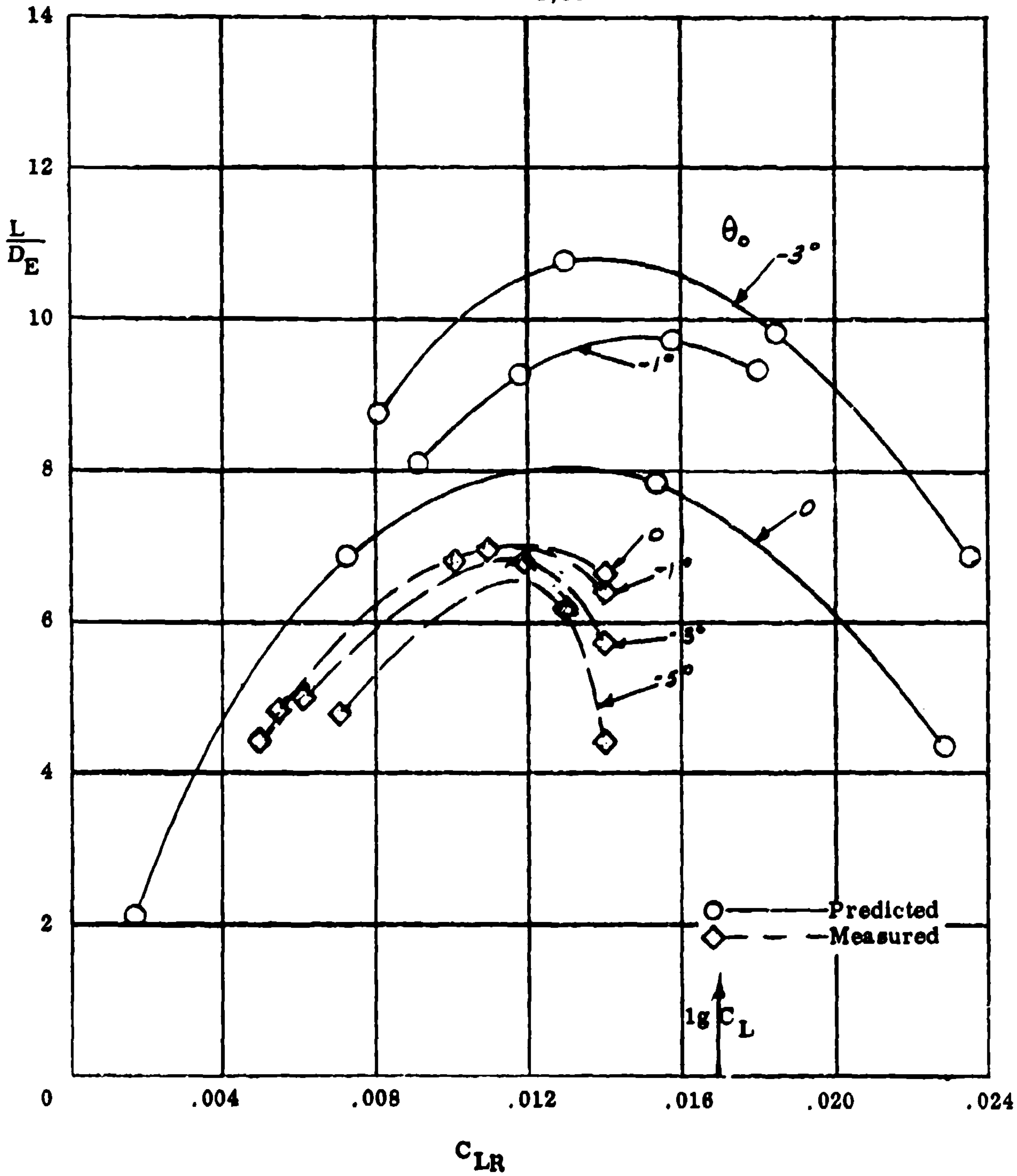
μ = .82, 1170 r.p.m., 243 knots, $M_{1,\ 90}$ = .65, ρ = .0021, run 56



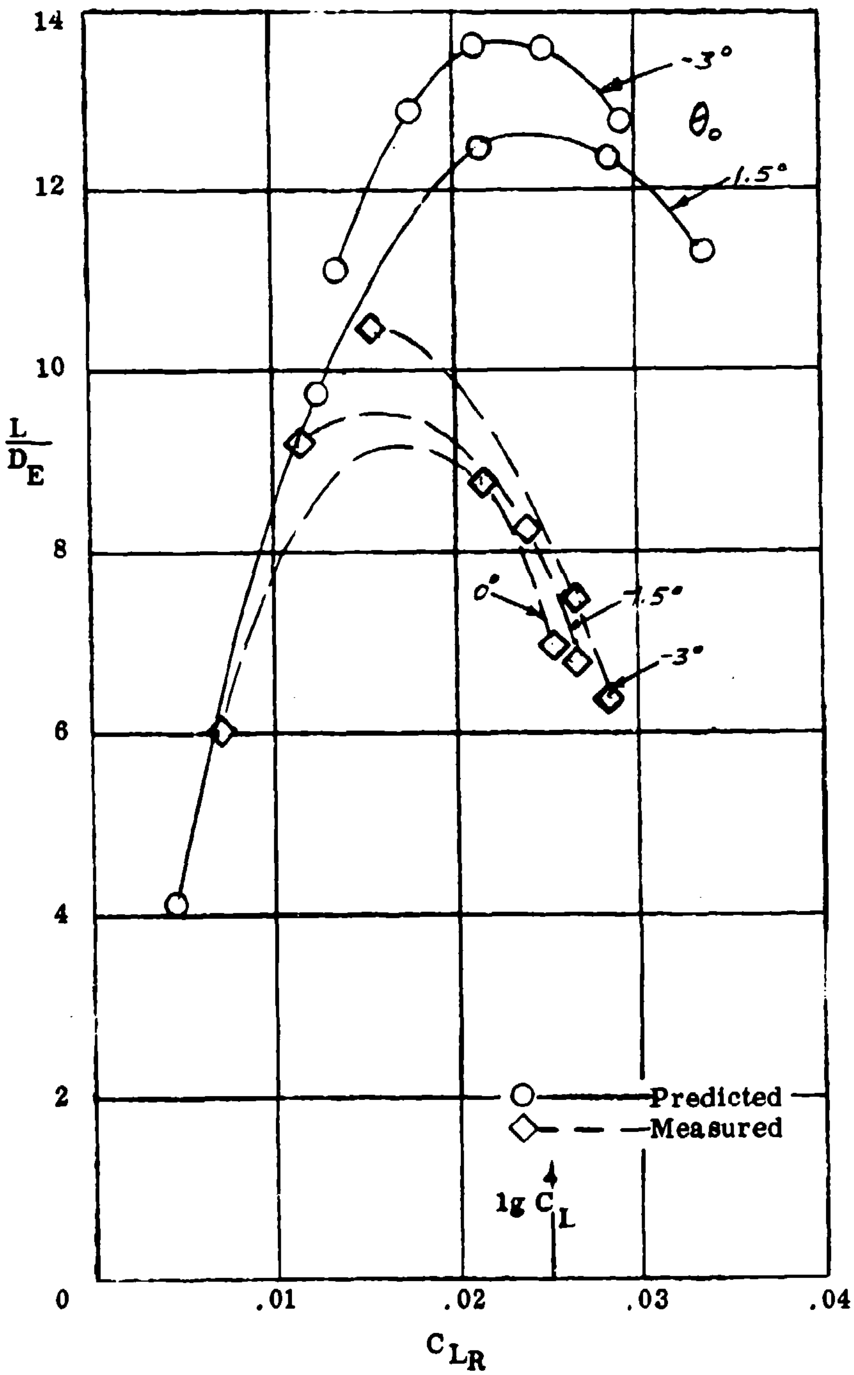
COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE
μ = .94, 1050 r.p.m., 243 knots, $M_{1,90}$ = .68, ρ = .0021, run 55



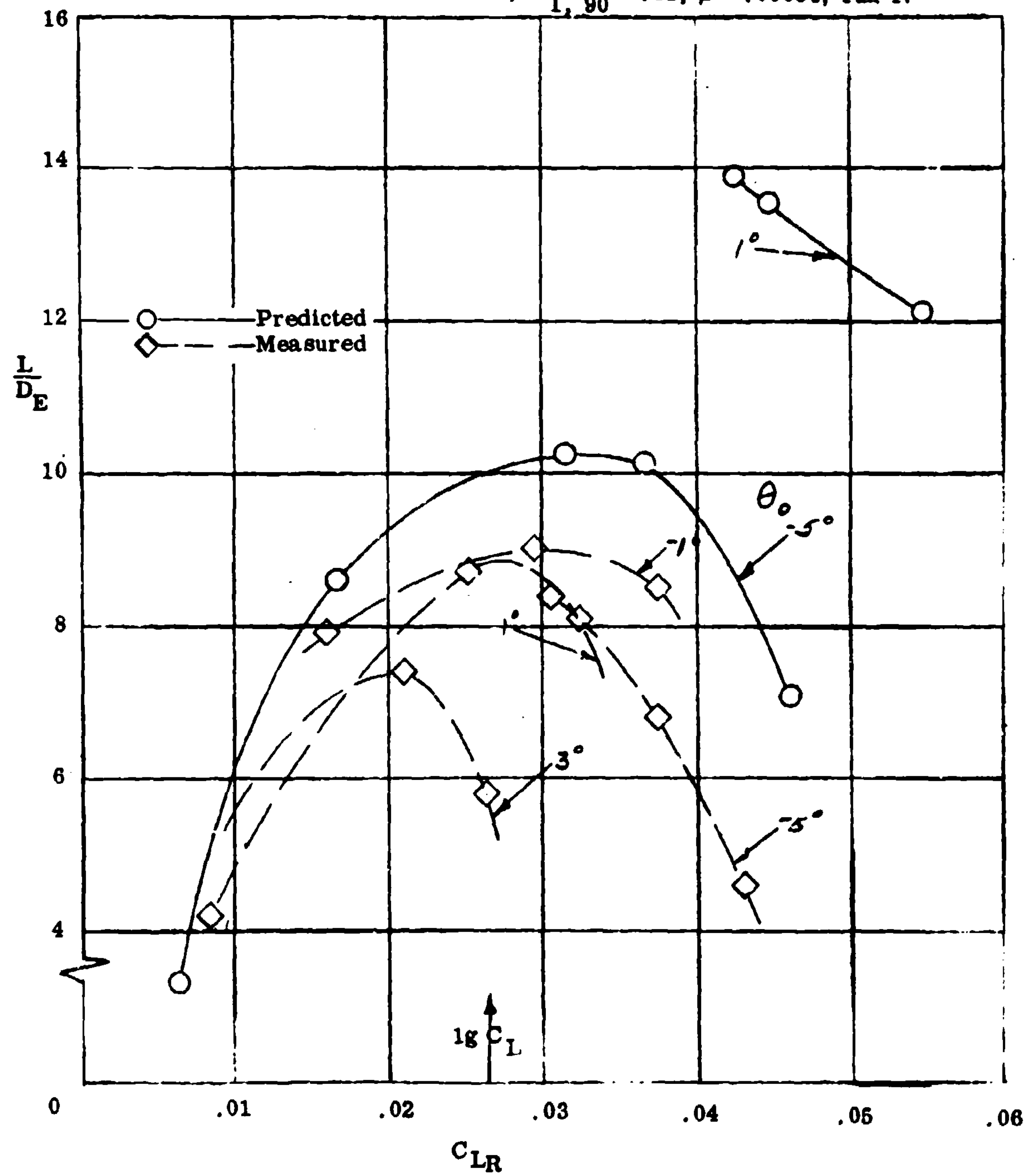
COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE
μ = 1.15, 833 r.p.m., 239 knots, $M_{1,90}$ = .66, ρ = .0021, run 54



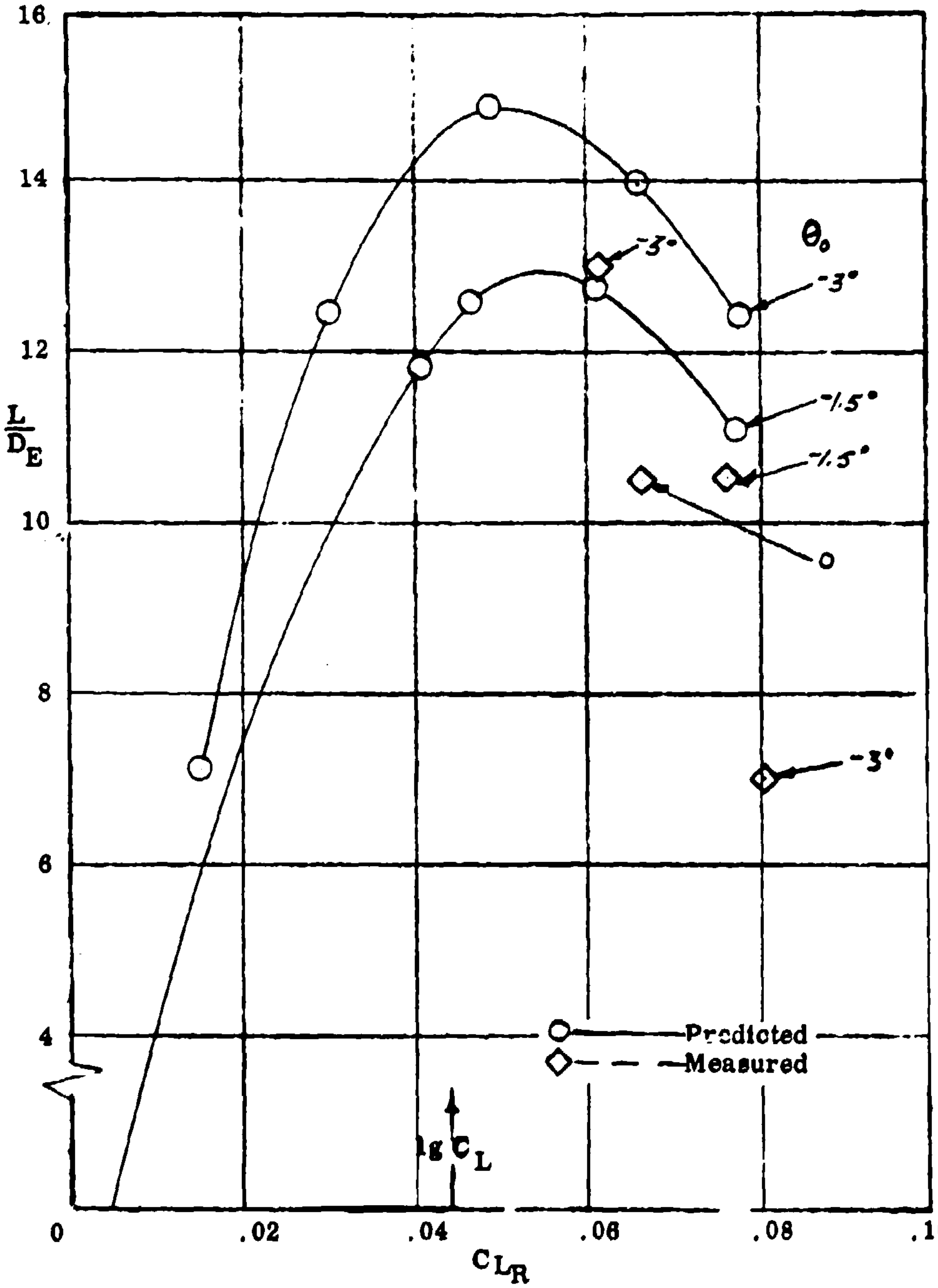
COMPARISON OF PREDICTED AND MEASURED ROTOR PEFORMANCE
μ = 1.50, 660 r.p.m., 243 knots, $M_{1,90}$ = .59, ρ = .0021, run 53



COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE
μ = 1.66, 833 r.p.m., 346 knots, $M_{1,\,90}$ = .81, ρ = .00084, run 47



COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE
$\mu = 2.16$, 643 r.p.m., 347 knots, $M_{1,\ 90} = .75$, $\rho = .00084$, run 48



COMPARISON OF PREDICTED AND MEASURED ROTOR PERFORMANCE
$\mu = 2.47$, 560 r.p.m., 350 knots, $M_{1,\,90} = .72$, $\rho = .00084$, run 49

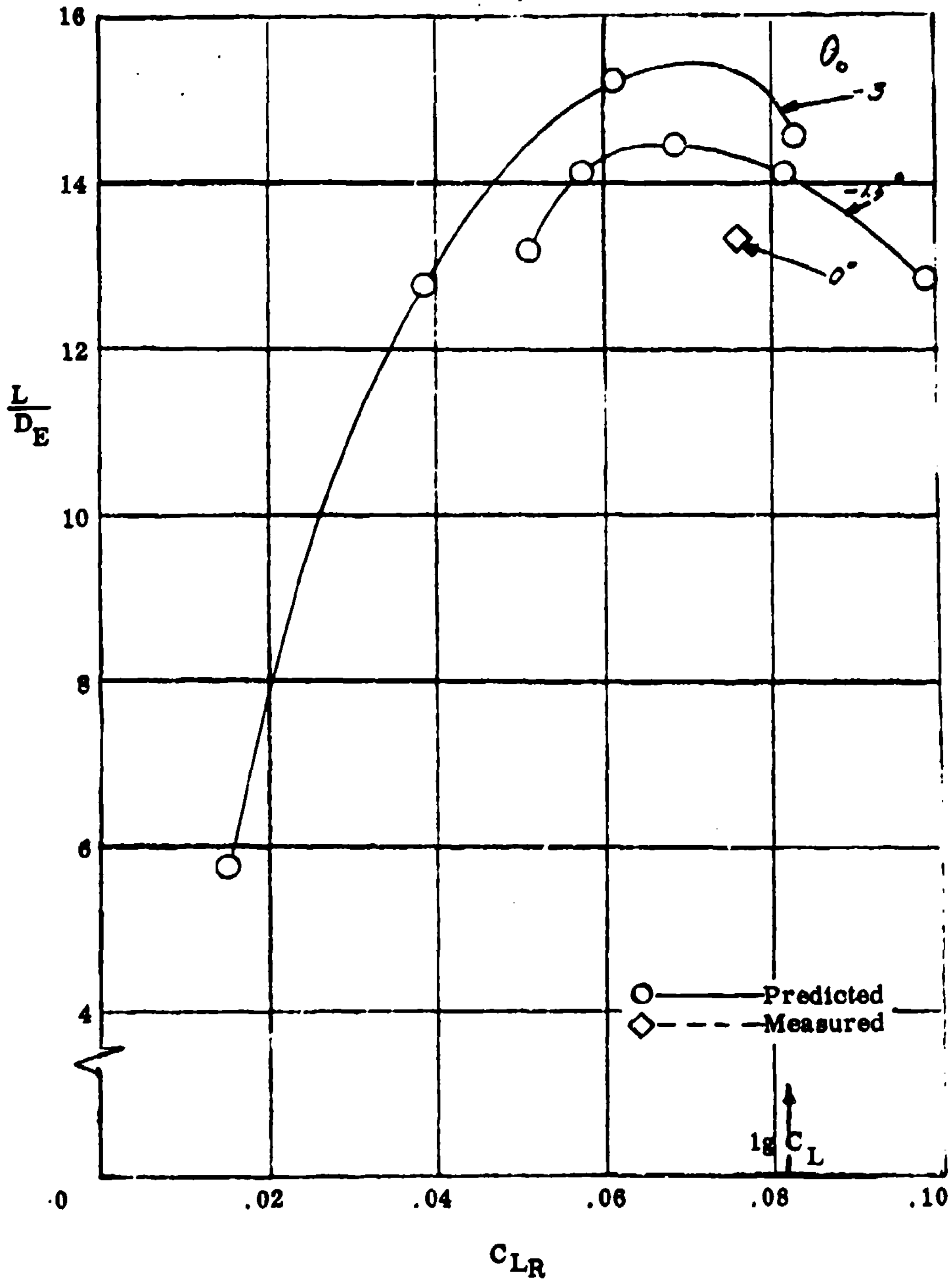


Figure 5.13

COMPARISON OF MEASURED AND PREDICTED MAXIMUM EFFECTIVE LIFT/DRAG RATIO - ADVANCE RATIOS 0.3 TO 2.5
(From Figures 5.2 Through 5.12)

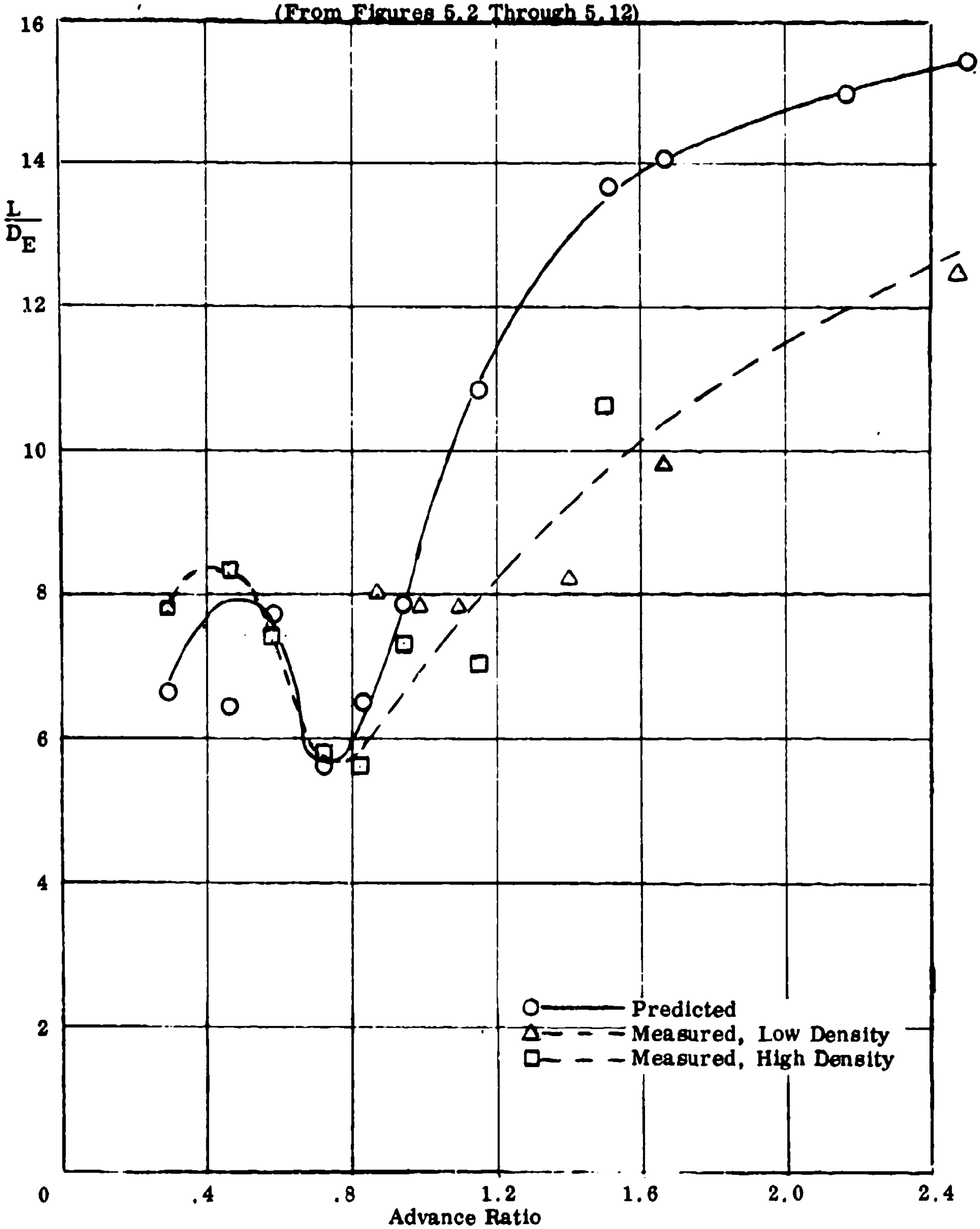
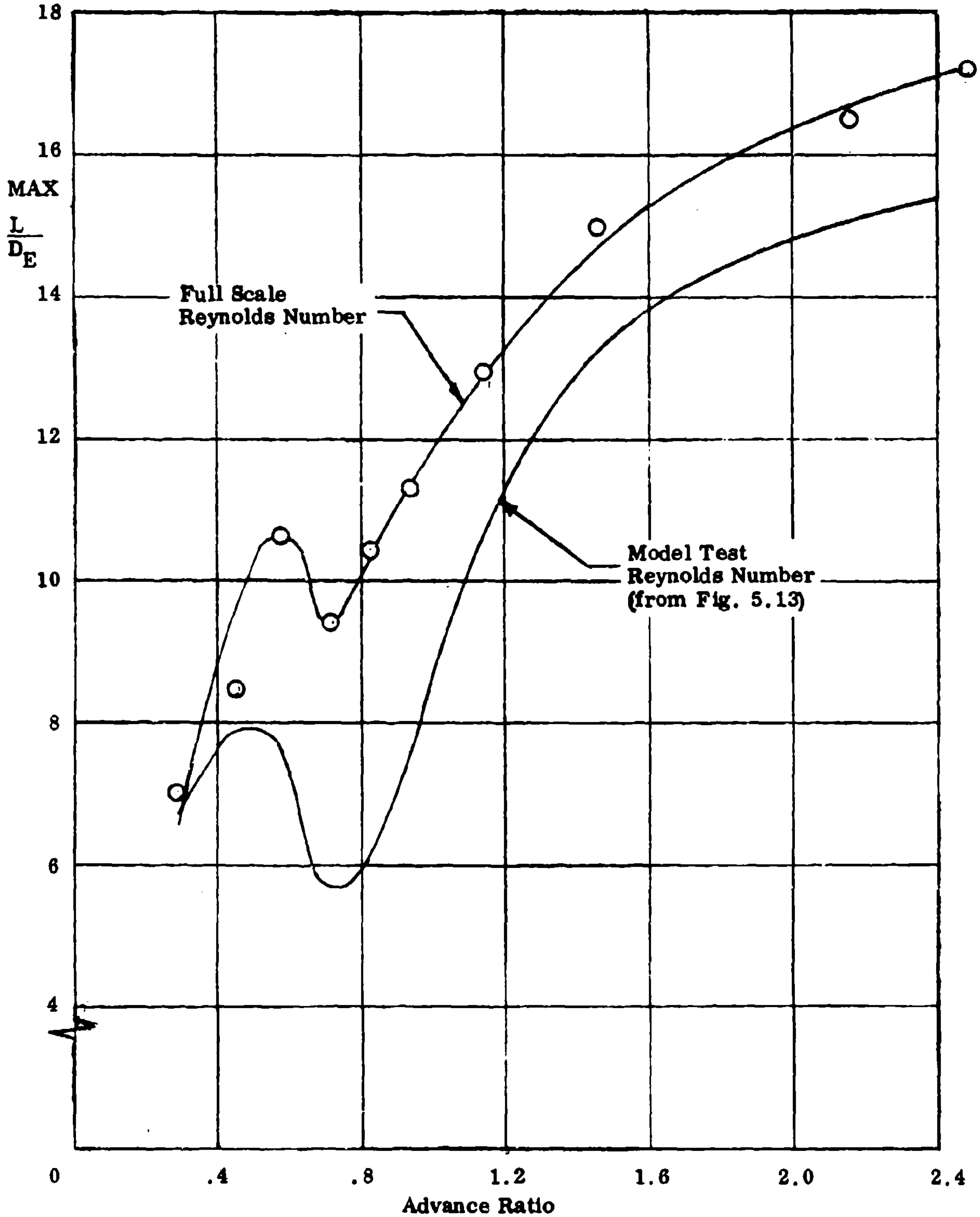


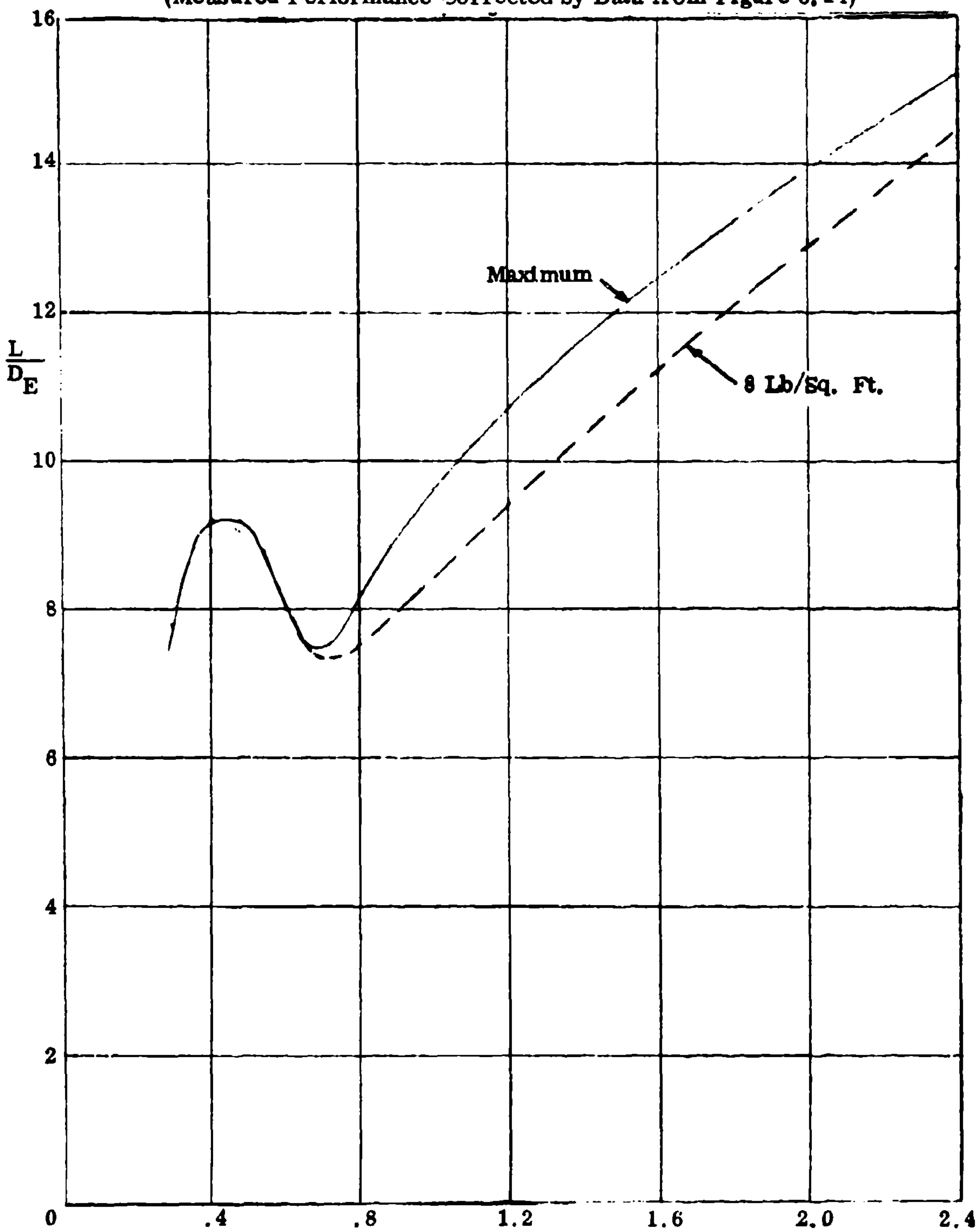
Figure 5.14

EFFECT OF REYNOLDS NUMBER ON PREDICTED ROTOR PERFORMANCE - MODEL ROTOR, 18% TO 6%

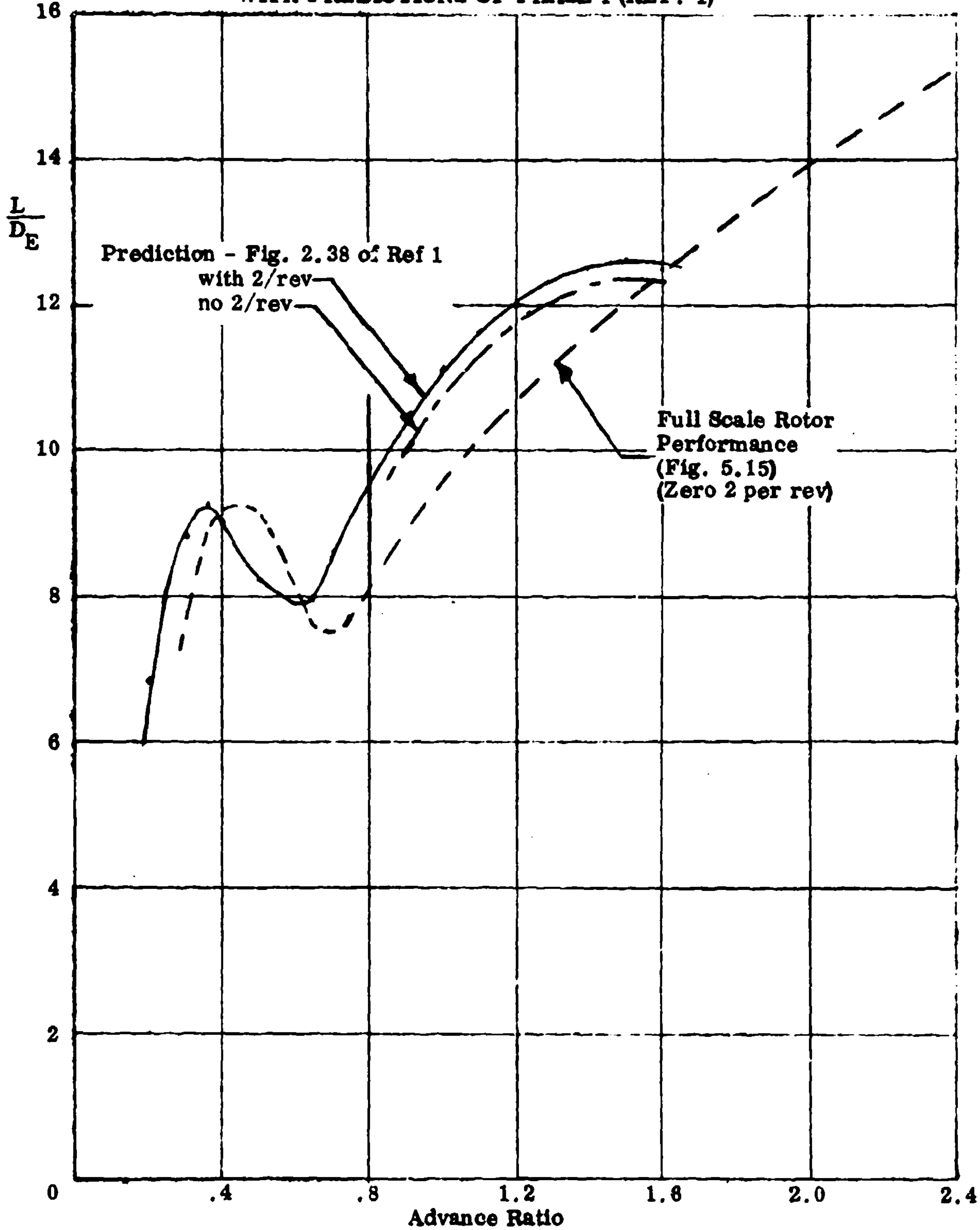


FULL-SCALE EFFECTIVE LIFT-DRAG RATIO -
MAXIMUM AND AT 8 LB. PER SQ. FT. DISK LOADING

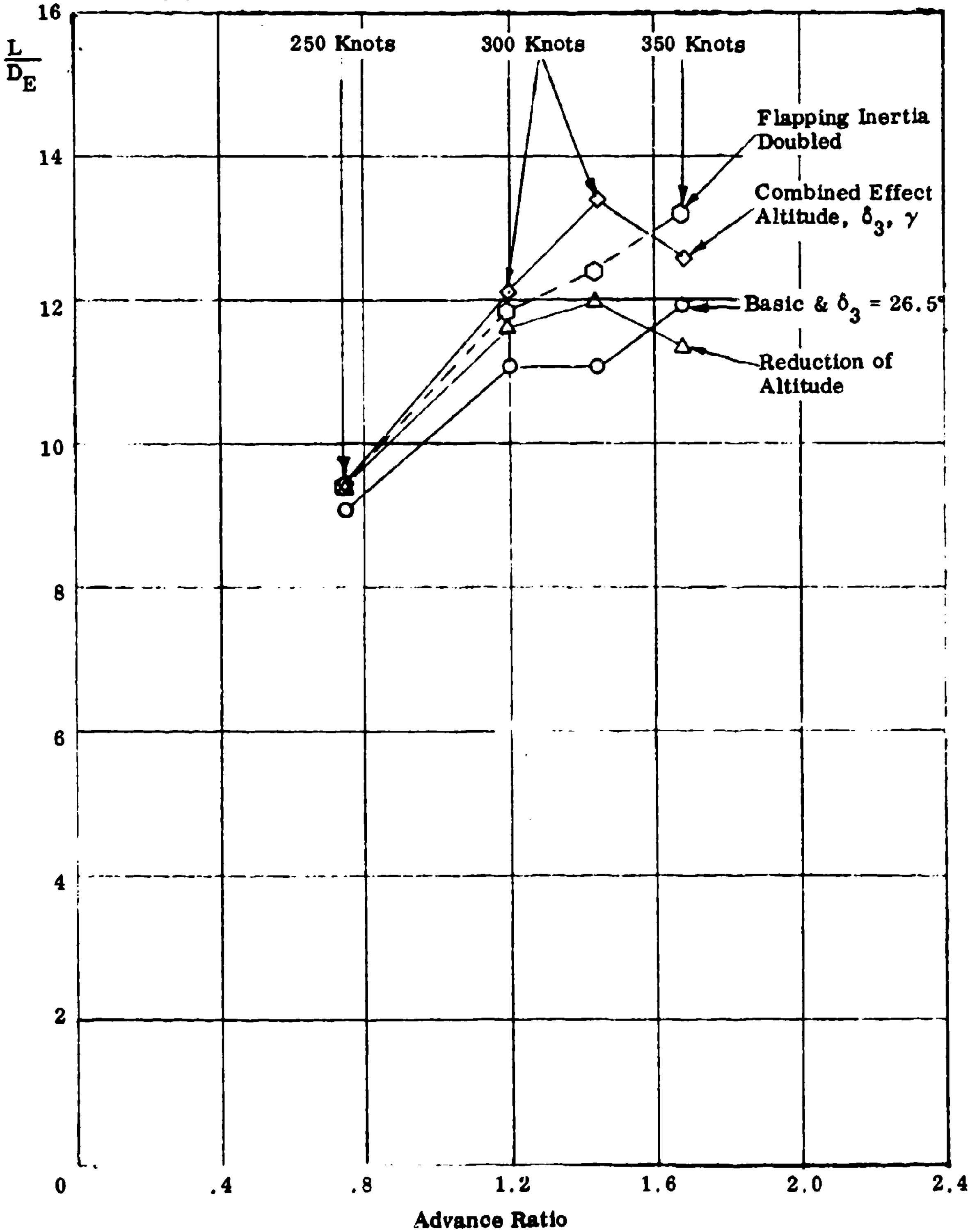
(Measured Performance Corrected by Data from Figure 5.14)



COMPARISON OF FULL-SCALE ROTOR PERFORMANCE
WITH PREDICTIONS OF PHASE I (REF. 1)



EFFECT OF CHANGE OF DELTA-3, LOCK NUMBER AND ALTITUDE ON PERFORMANCE OF PHASE I ROTOR



APPENDIX A
AIRFOIL SECTION DEVELOPMENT

A1 General

The airfoil sections used in the blade design have been completely defined on a mathematical basis, that is, they are derived from separate equations defining the camber line ordinates and thickness distribution. These equations have been coded in Fairchild Republic digital computer program RAD T620279, and can be used to generate a wide variety of airfoil shapes with either rounded trailing-edge thickness distributions suitable for the RVR concept or conventional sharp trailing edge forms.

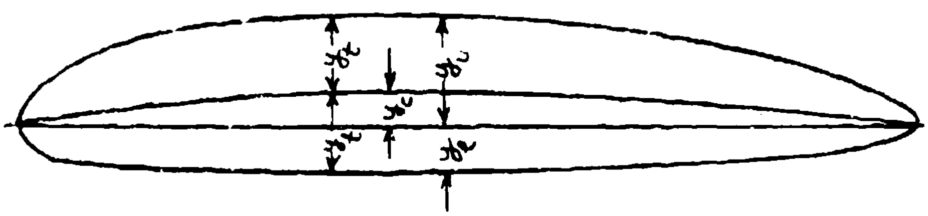
A2 Mathematical Airfoil Definition

A2.1 Surface Ordinates

The upper and lower surface ordinates, y_u and y_ℓ, respectively are determined from the following relations (see sketch)

$$y_u = y_c + y_t \qquad (1)$$

$$y_\ell = y_c - y_t \qquad (2)$$



where y_c and y_t devote the mathematical camber line and thickness distribution function respectively, described next.

A2.2 Thickness Distribution

Two separate functions are used to generate the thickness distribution: one equation is used forward of the maximum thickness location; and another for the portion aft of that location. Thus for the fore section, that is, for $0 \le x \le x_t$ (where x_t location, in fraction of chord, of maximum thickness)

$$y_t = b_0 \sqrt{x} + b_1 + b_2 x^2 \qquad (3)$$

and for the aft section i.e., for $x_t \le x \le 1.0$

$$y_t = c_0\sqrt{1-x} + c_1(1-x) + c_2(1-x)^2 + c_3(1-x)^3 \qquad (4)$$

It is to be noted that these functions representing the fore and aft sections of the thickness distribution are constrained to have the same value of the second derivative at the "join", which is taken to be the station, $x = x_t$, at which the thickness is maximum. This ensures that the curvature of the thickness distribution is continuous along the length of the airfoil.

It should also be noted that the coordinates x and y_t appearing here are dimensionless, that is to say, they have been normalized with respect to the chord length, c.

The coefficients of the various terms in equations (1) and (2) above are dependent upon the following geometric parameters:

x_t = chordwise location of maximum thickness

$r_{\ell e}$ = leading edge radius (fraction of chord)

t_m = semi-maximum thickness ratio

r_{te} = trailing edge semi-thickness

A2.2 Camber line

The camber line function y_c is given by two curves, one for the camber line portion forward of the maximum camber location, and one for the portion aft of this location. Thus, for $x \le x_c$ (where x_c = max camber location fraction of chord):

$$y_c = a_1x + a_2x^2 + a_3x^3 \qquad (5)$$

and for $x \ge x_c$

$$y_c = d_1(1-x) + d_2(1-x)^2 + d_3(1-x)^3 + d_4(1-x)^4 \qquad (6)$$

The coefficients in the equations (5) and (6) are determined by the following geometric parameters, together with the requirement that the second derivative (and hence the camber line curvature) be continuous at the join of the fore and aft section camber lines:

x_c = chordwise location of maximum camber

c_m = maximum camber, fraction of chord

c_b = slope of camber line at leading edge

c_e = slope of camber line at trailing edge

A3 Sections Developed for the Model

For all sections used on the blade the maximum thickness and maximum camber are both located at 40% chord: For the root section of the rotor an 18% thick section with 3.7% camber was selected. The tip section is of 6% thickness with 1.3% camber. This reduced camber in the tip section was dictated by manufacturing considerations, in that avoidance of concavity on the under surface of the blade led to a significant reduction of cost. Use of 1.3% camber at the tip eliminated the concavity that would have resulted has a 2-1/2% camber been used along the entire blade. Consequently, the section at the semi-span station is of 12% thickness with 2.5% camber.

Tabulated ordinates for the root (18%) and tip (6%) sections are given in tables A-I and A-II, and the sections are illustrated in Figure 1.4 of the main report.

It is noted that the sections selected for the rotor differ slightly from the modified 0012 section tested previously (Ref. 1). The difference in geometry is restricted to the region of the trailing region and consists primarily of a slight thickening and a better shaped round trailing edge based on the above mentioned mathematical approach which is described briefly below. These changes were expected to yield an improvement in maximum lift coefficients for both forward and reverse flow, as well as improved transonic aerodynamic characteristics.

TABLE A-1. AIRFOIL SECTION DEVELOPMENT - INPUT PARAMETERS

Input Parameters	Root Section	Tip Section
Max Camber Location, x_c	.400000	.400000
Max Thickness Location, x_t	.400000	.400000
Trailing Edge Semi-Thickness	0	0
Trailing Edge Semi-Angle	0	0
Max Semi-Thickness, t_m	.090000	.030000
Max Camber, c_m	.037000	.013000
Slope of Camber Line at Trailing Edge, c_e	.148000	.052000
Slope of Camber Line at Leading Edge, c_b	.222000	.078000
Leading Edge Radius R_L	.039487	.004387
Trailing Edge Radius, R_T	.010000	.002870

TABLE A-II. ORDINATES OF ROOT AIRFOIL SECTION
18 Percent Thick, 3.7 Percent Camber

	x	y_u	y_ℓ	y_c	y_t	$2y_t$
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.005000	0.019888	-0.017689	0.001100	0.018789	0.037577
3	0.010000	0.028115	-0.023758	0.002179	0.025937	0.051873
4	0.015000	0.034406	-0.027932	0.003237	0.031169	0.062338
5	0.020000	0.039685	-0.031135	0.004275	0.035410	0.070820
6	0.025000	0.044310	-0.033723	0.005293	0.039017	0.078034
7	0.030000	0.048465	-0.035882	0.006292	0.042173	0.084347
8	0.035000	0.052258	-0.037719	0.007270	0.044988	0.089977
9	0.040000	0.055762	-0.039304	0.008229	0.047533	0.095067
10	0.045000	0.059025	-0.040689	0.009168	0.049857	0.099714
11	0.050000	0.062084	-0.041908	0.010088	0.051996	0.103992
12	0.055000	0.064966	-0.042987	0.010989	0.053977	0.107954
13	0.060000	0.067692	-0.043949	0.011871	0.055821	0.111641
14	0.065000	0.070279	-0.044810	0.012735	0.057545	0.115089
15	0.070000	0.072742	-0.045582	0.013580	0.059162	0.118324
16	0.075000	0.075090	-0.046278	0.014406	0.060684	0.121368
17	0.080000	0.077334	-0.046905	0.015214	0.062120	0.124240
18	0.085000	0.079482	-0.047473	0.016005	0.063478	0.126955
19	0.090000	0.081541	-0.047987	0.016777	0.064764	0.129529
20	0.095000	0.083517	-0.048454	0.017532	0.065985	0.131971
21	0.100000	0.085415	-0.048877	0.018269	0.067146	0.134292
22	0.110000	0.088995	-0.049613	0.019691	0.069304	0.138609
23	0.120000	0.092313	-0.050221	0.021046	0.071267	0.142534
24	0.130000	0.095393	-0.050726	0.022333	0.073059	0.146119
25	0.140000	0.098256	-0.051144	0.023556	0.074700	0.149400
26	0.150000	0.100920	-0.051490	0.024715	0.076205	0.152410
27	0.160000	0.103399	-0.051776	0.025811	0.077587	0.155175
28	0.170000	0.105705	-0.052012	0.026847	0.078859	0.157717
29	0.180000	0.107850	-0.052206	0.027822	0.080028	0.160056
30	0.190000	0.109843	-0.052364	0.028740	0.081104	0.162208
31	0.200000	0.111693	-0.052493	0.029600	0.082093	0.164187
32	0.210000	0.113408	-0.052598	0.030405	0.083003	0.166006
33	0.220000	0.114994	-0.052682	0.031156	0.083838	0.167676
34	0.230000	0.116457	-0.052749	0.031854	0.084603	0.169207
35	0.240000	0.117805	-0.052803	0.032501	0.085304	0.170608
36	0.250000	0.119041	-0.052845	0.033098	0.085943	0.171886
37	0.260000	0.120170	-0.052879	0.033646	0.086524	0.173049
38	0.270000	0.121199	-0.052904	0.034147	0.087052	0.174103
39	0.280000	0.122130	-0.052925	0.034602	0.087527	0.175054
40	0.290000	0.122967	-0.052941	0.035013	0.087954	0.175908
41	0.300000	0.123715	-0.052953	0.035381	0.088334	0.176668
42	0.310000	0.124378	-0.052963	0.035708	0.088670	0.177340
43	0.320000	0.124958	-0.052971	0.035994	0.088964	0.177928
44	0.330000	0.125459	-0.052977	0.036241	0.089218	0.178436
45	0.340000	0.125884	-0.052983	0.036451	0.089433	0.178866
46	0.350000	0.126236	-0.052987	0.036624	0.089612	0.179223
47	0.360000	0.126518	-0.052991	0.036763	0.089755	0.179509
48	0.370000	0.126733	-0.052995	0.036869	0.089864	0.179727
49	0.380000	0.126883	-0.052998	0.036943	0.089940	0.179880
50	0.390000	0.126971	-0.052999	0.036986	0.089985	0.179970
51	0.400000	0.127000	-0.053000	0.037000	0.090000	0.180000
52	0.410000	0.126972	-0.052999	0.036986	0.089985	0.179971
53	0.420000	0.126887	-0.052996	0.036946	0.089942	0.179883
54	0.430000	0.126748	-0.052988	0.036880	0.089868	0.179736
55	0.440000	0.126555	-0.052976	0.036790	0.089765	0.179531
56	0.450000	0.126308	-0.052958	0.036675	0.089633	0.179266
57	0.460000	0.126009	-0.052933	0.036538	0.089471	0.178942
58	0.470000	0.125659	-0.052899	0.036380	0.089279	0.178558
59	0.480000	0.125257	-0.052857	0.036200	0.089057	0.178114
60	0.490000	0.124803	-0.052805	0.035999	0.088805	0.177609
61	0.500000	0.124301	-0.052742	0.035780	0.088522	0.177044

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TABLE A-II (Continued)

	x	y_u	y_ℓ	y_c	y_t	$2y_t$
62	0.510000	0.123749	-0.052669	0.035541	0.088209	0.176418
63	0.520000	0.123148	-0.052582	0.035283	0.087865	0.175730
64	0.530000	0.122498	-0.052482	0.035008	0.087490	0.174979
65	0.540000	0.121799	-0.052368	0.034715	0.087083	0.174167
66	0.550000	0.121051	-0.052240	0.034406	0.086646	0.173291
67	0.560000	0.120256	-0.052097	0.034079	0.086176	0.172352
68	0.570000	0.119412	-0.051937	0.033737	0.085675	0.171349
69	0.580000	0.118519	-0.051762	0.033379	0.085140	0.170281
70	0.590000	0.117578	-0.051569	0.033004	0.084574	0.169147
71	0.600000	0.116588	-0.051359	0.032615	0.083974	0.167947
72	0.610000	0.115550	-0.051130	0.032210	0.083340	0.166680
73	0.520000	0.114462	-0.050883	0.031789	0.082673	0.165345
74	0.630000	0.113324	-0.050617	0.031354	0.081971	0.163941
75	0.640000	0.112136	-0.050331	0.030902	0.081234	0.162468
76	0.650000	0.110897	-0.050025	0.030436	0.080461	0.160923
77	0.660000	0.109606	-0.049699	0.029954	0.079653	0.159305
78	0.670000	0.108263	-0.049351	0.029456	0.078807	0.157614
79	0.680000	0.106866	-0.048982	0.028942	0.077924	0.155848
80	0.690000	0.105415	-0.048591	0.028412	0.077003	0.154006
81	0.700000	0.103908	-0.048177	0.027866	0.076043	0.152085
82	0.710000	0.102344	-0.047740	0.027302	0.075042	0.150084
83	0.720000	0.100721	-0.047279	0.026721	0.074000	0.149001
84	0.730000	0.099039	-0.046794	0.026122	0.072916	0.145833
85	0.740000	0.097294	-0.046284	0.025505	0.071789	0.143578
86	0.750000	0.095486	-0.045748	0.024869	0.070617	0.141234
87	0.760000	0.093611	-0.045186	0.024213	0.069398	0.138797
88	0.770000	0.091668	-0.044595	0.023537	0.068132	0.136264
89	0.780000	0.089654	-0.043976	0.022839	0.066815	0.133630
90	0.790000	0.087566	-0.043327	0.022120	0.065447	0.130893
91	0.800000	0.085401	-0.042646	0.021378	0.064024	0.128047
92	0.810000	0.083156	-0.041931	0.020612	0.062543	0.125087
93	0.820000	0.080825	-0.041181	0.019822	0.061003	0.122006
94	0.830000	0.078405	-0.040393	0.019006	0.059399	0.118798
95	0.840000	0.075891	-0.039564	0.018163	0.057727	0.115454
96	0.850000	0.073276	-0.038690	0.017293	0.055983	0.111966
97	0.860000	0.070558	-0.037767	0.016394	0.054161	0.108322
98	0.870000	0.067719	-0.036789	0.015465	0.052254	0.104508
99	0.880000	0.064759	-0.035751	0.014504	0.050255	0.100509
100	0.890000	0.061664	-0.034643	0.013511	0.048153	0.096307
101	0.900000	0.059422	-0.033455	0.012483	0.045938	0.091877
102	0.905000	0.056740	-0.032827	0.011955	0.044784	0.089567
103	0.910000	0.055015	-0.032174	0.011420	0.043595	0.087189
104	0.915000	0.053244	-0.031493	0.010875	0.042369	0.084737
105	0.920000	0.051423	-0.030782	0.010321	0.041103	0.082206
106	0.925000	0.049550	-0.030039	0.009756	0.039794	0.079588
107	0.930000	0.047620	-0.029255	0.009182	0.038438	0.076875
108	0.935000	0.045628	-0.028431	0.008598	0.037030	0.074060
109	0.940000	0.043568	-0.027560	0.008004	0.035564	0.071129
110	0.945000	0.041434	-0.026635	0.007399	0.034034	0.068069
111	0.950000	0.039216	-0.025649	0.006784	0.032432	0.064864
112	0.955000	0.036904	-0.024588	0.006159	0.030746	0.061492
113	0.960000	0.034494	-0.023442	0.005521	0.028963	0.057927
114	0.965000	0.031938	-0.022193	0.004873	0.027066	0.054131
115	0.970000	0.029241	-0.020815	0.004213	0.025028	0.050056
116	0.975000	0.026356	-0.019273	0.003541	0.022815	0.045629
117	0.980000	0.023229	-0.017513	0.002858	0.020371	0.040742
118	0.985000	0.019767	-0.015443	0.002162	0.017605	0.035209
119	0.990000	0.015790	-0.012881	0.001454	0.014335	0.028671
120	0.995000	0.010832	-0.009365	0.000733	0.010099	0.020197
121	1.000000	0.000000	-0.000000	0.000000	0.000000	0.000000

TABLE A-III. ORDINATES OF TIP AIRFOIL SECTION

6 Percent Thick, 1.3 Percent Camber

	x	y_u	y_ℓ	y_c	y_t	$2y_t$
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.005000	0.006649	-0.005877	0.000386	0.006263	0.012526
3	0.010000	0.009411	-0.007881	0.000765	0.008646	0.017291
4	0.015000	0.011527	-0.009252	0.001137	0.010390	0.020779
5	0.020000	0.013305	-0.010301	0.001502	0.011803	0.023607
6	0.025000	0.014865	-0.011146	0.001860	0.013006	0.026011
7	0.030000	0.016269	-0.011847	0.002211	0.014058	0.028116
8	0.035000	0.017550	-0.012442	0.002554	0.014996	0.029992
9	0.040000	0.018736	-0.012953	0.002891	0.015844	0.031689
10	0.045000	0.019840	-0.013398	0.003221	0.016619	0.033238
11	0.050000	0.020877	-0.013787	0.003545	0.017332	0.034664
12	0.055000	0.021953	-0.014131	0.003861	0.017992	0.035985
13	0.060000	0.022778	-0.014436	0.004171	0.018607	0.037214
14	0.065000	0.023655	-0.014707	0.004474	0.019182	0.038363
15	0.070000	0.024492	-0.014949	0.004771	0.019721	0.039441
16	0.075000	0.025290	-0.015166	0.005062	0.020228	0.040456
17	0.080000	0.026052	-0.015361	0.005346	0.020707	0.041413
18	0.085000	0.026782	-0.015536	0.005623	0.021159	0.042318
19	0.090000	0.027483	-0.015694	0.005895	0.021588	0.043176
20	0.095000	0.028155	-0.015835	0.006160	0.021995	0.043990
21	0.100000	0.028801	-0.015963	0.006419	0.022382	0.044764
22	0.110000	0.030020	-0.016183	0.006919	0.023101	0.046203
23	0.120000	0.031159	-0.016361	0.007394	0.023756	0.047511
24	0.130000	0.032200	-0.016506	0.007847	0.024353	0.048706
25	0.140000	0.033176	-0.016624	0.008276	0.024900	0.049800
26	0.150000	0.034085	-0.016718	0.008684	0.025402	0.050803
27	0.160000	0.034931	-0.016794	0.009069	0.025862	0.051725
28	0.170000	0.035719	-0.016854	0.009433	0.026286	0.052572
29	0.180000	0.036451	-0.016901	0.009775	0.026676	0.053352
30	0.190000	0.037132	-0.016937	0.010098	0.027035	0.054069
31	0.200000	0.037764	-0.016964	0.010400	0.027364	0.054729
32	0.210000	0.038350	-0.016985	0.010683	0.027668	0.055335
33	0.220000	0.038893	-0.016999	0.010947	0.027946	0.055892
34	0.230000	0.039393	-0.017009	0.011192	0.028201	0.056402
35	0.240000	0.039854	-0.017015	0.011419	0.028435	0.056869
36	0.250000	0.040277	-0.017019	0.011629	0.028648	0.057296
37	0.260000	0.040663	-0.017020	0.011822	0.028841	0.057683
38	0.270000	0.041015	-0.017020	0.011998	0.029017	0.058034
39	0.280000	0.041333	-0.017018	0.012158	0.029176	0.058351
40	0.290000	0.041620	-0.017016	0.012302	0.029318	0.058636
41	0.300000	0.041876	-0.017013	0.012431	0.029445	0.058889
42	0.310000	0.042103	-0.017011	0.012546	0.029557	0.059113
43	0.320000	0.042301	-0.017008	0.012646	0.029655	0.059309
44	0.330000	0.042473	-0.017006	0.012733	0.029739	0.059479
45	0.340000	0.042618	-0.017004	0.012807	0.029811	0.059622
46	0.350000	0.042739	-0.017003	0.012868	0.029871	0.059741
47	0.360000	0.042835	-0.017001	0.012917	0.029918	0.059836
48	0.370000	0.042909	-0.017001	0.012954	0.029955	0.059909
49	0.380000	0.042960	-0.017000	0.012980	0.029980	0.059960
50	0.390000	0.042990	-0.017000	0.012995	0.029995	0.059990
51	0.400000	0.043000	-0.017000	0.013000	0.030000	0.060000
52	0.410000	0.042990	-0.017000	0.012995	0.029995	0.059990
53	0.420000	0.042962	-0.017000	0.012981	0.029981	0.059962
54	0.430000	0.042915	-0.016999	0.012958	0.029957	0.059914
55	0.440000	0.042850	-0.016998	0.012926	0.029924	0.059848
56	0.450000	0.042768	-0.016996	0.012886	0.029882	0.059763
57	0.460000	0.042668	-0.016993	0.012838	0.029830	0.059661
58	0.470000	0.042552	-0.016988	0.012782	0.029770	0.059541
59	0.480000	0.042420	-0.016983	0.012719	0.029701	0.059403
60	0.490000	0.042272	-0.016976	0.012649	0.029624	0.059248
61	0.500000	0.042109	-0.016967	0.012571	0.029538	0.059076

TABLE A-III (Continued)

	x	y_u	y_ℓ	y_c	y_t	$2y_t$
62	0.510000	0.041931	-0.016956	0.012487	0.029444	0.058887
63	0.520000	0.041738	-0.016944	0.012397	0.029341	0.058682
64	0.530000	0.041530	-0.016930	0.012300	0.029230	0.058460
65	0.540000	0.041309	-0.016914	0.012197	0.029111	0.058222
66	0.550000	0.041077	-0.016896	0.012088	0.028984	0.057968
67	0.560000	0.040823	-0.016875	0.011974	0.028849	0.057698
68	0.570000	0.040559	-0.016852	0.011854	0.028706	0.057412
69	0.580000	0.040282	-0.016827	0.011728	0.028555	0.057110
70	0.590000	0.039992	-0.016800	0.011596	0.028396	0.056792
71	0.600000	0.039689	-0.016770	0.011459	0.028229	0.056458
72	0.610000	0.039371	-0.016737	0.011317	0.028054	0.056109
73	0.620000	0.039041	-0.016702	0.011169	0.027872	0.055743
74	0.630000	0.038697	-0.016665	0.011016	0.027681	0.055362
75	0.640000	0.038340	-0.016625	0.010858	0.027482	0.054964
76	0.650000	0.037969	-0.016582	0.010694	0.027276	0.054550
77	0.660000	0.037584	-0.016536	0.010524	0.027060	0.054120
78	0.670000	0.037186	-0.016487	0.010349	0.026836	0.053673
79	0.680000	0.036773	-0.016435	0.010169	0.026604	0.053208
80	0.690000	0.036346	-0.016381	0.009983	0.026363	0.052727
81	0.700000	0.035904	-0.016323	0.009791	0.026113	0.052227
82	0.710000	0.035447	-0.016261	0.009593	0.025854	0.051708
83	0.720000	0.034975	-0.016196	0.009389	0.025585	0.051170
84	0.730000	0.034486	-0.016129	0.009178	0.025306	0.050612
85	0.740000	0.033977	-0.016055	0.008961	0.025016	0.050032
86	0.750000	0.033453	-0.015978	0.008738	0.024716	0.049431
87	0.760000	0.032911	-0.015896	0.008507	0.024403	0.048807
88	0.770000	0.032348	-0.015809	0.008270	0.024079	0.048157
89	0.780000	0.031766	-0.015716	0.008025	0.023741	0.047482
90	0.790000	0.031161	-0.015617	0.007772	0.023389	0.046778
91	0.800000	0.030533	-0.015511	0.007511	0.023022	0.046045
92	0.810000	0.029881	-0.015397	0.007242	0.022639	0.045278
93	0.820000	0.029203	-0.015274	0.006964	0.022238	0.044477
94	0.830000	0.028496	-0.015140	0.006678	0.021818	0.043636
95	0.840000	0.027758	-0.014994	0.006381	0.021376	0.042752
96	0.850000	0.026987	-0.014835	0.006076	0.020911	0.041822
97	0.860000	0.026179	-0.014659	0.005760	0.020419	0.040838
98	0.870000	0.025331	-0.014464	0.005434	0.019898	0.039795
99	0.880000	0.024439	-0.014247	0.005096	0.019343	0.038686
100	0.890000	0.023498	-0.014002	0.004747	0.018749	0.037498
101	0.900000	0.022497	-0.013725	0.004386	0.018111	0.036222
102	0.905000	0.021973	-0.013572	0.004201	0.017773	0.035545
103	0.910000	0.021433	-0.013408	0.004013	0.017420	0.034840
104	0.915000	0.020873	-0.013231	0.003821	0.017052	0.034105
105	0.920000	0.020293	-0.013041	0.003626	0.016667	0.033335
106	0.925000	0.019691	-0.012836	0.003428	0.016264	0.032527
107	0.930000	0.019065	-0.012613	0.003226	0.015839	0.031678
108	0.935000	0.018412	-0.012370	0.003021	0.015391	0.030781
109	0.940000	0.017728	-0.012104	0.002812	0.014916	0.029832
110	0.945000	0.017011	-0.011812	0.002600	0.014412	0.028823
111	0.950000	0.016258	-0.011489	0.002384	0.013873	0.027746
112	0.955000	0.015458	-0.011130	0.002164	0.013294	0.026588
113	0.960000	0.014608	-0.010728	0.001940	0.012668	0.025336
114	0.965000	0.013697	-0.010273	0.001712	0.011985	0.023970
115	0.970000	0.012717	-0.009757	0.001480	0.011237	0.022474
116	0.975000	0.011634	-0.009146	0.001244	0.010390	0.020780
117	0.980000	0.010434	-0.008426	0.001004	0.009430	0.018860
118	0.985000	0.009062	-0.007543	0.000760	0.008303	0.016606
119	0.990000	0.007424	-0.006402	0.000511	0.006913	0.013826
120	0.995000	0.005270	-0.004755	0.000258	0.005013	0.010025
121	1.000000	0.000000	-0.000000	0.000000	0.000000	0.000000

APPENDIX B

ROTOR TEST RESULTS

Results are reproduced from NASA provided print-out. They have been corrected for tares. See Section 2.1.

KEY TO ABBREVIATIONS - ROTOR TEST RESULTS

M	M_∞	free-stream Mach number
R	R	Reynolds number, millions per foot
PT	P_{t_∞}	free-stream total pressure, lb per sq ft
Q	q_∞	free-stream dynamic pressure, lb per sq ft
TT	T_{t_∞}	free-stream total temperature, °F
RHO	ρ x100	free-stream density, slugs/ft^3
GAMA	γ	blade lock number ρ_∞ (a) (c) $(b^4)/I_\beta$
PHI	φ_2	two-per-rev phasing, degrees
DEL 3	δ_3	flapping hinge cant, degrees
CORR		data correlation number
THEZ	θ_o	collective pitch, degrees
THEC	θ_{1c}	cyclic pitch (cosine), degrees
THES	θ_{1s}	cyclic pitch (sine), degrees
ALFA	α	angle of attack of model reference axis, degrees
V	V_∞	free-stream velocity, ft/sec
VTIP	ΩR	tip speed, RPM (π/30) (b), ft/sec
MU	μ	advance ratio, $V_\infty (\cos\alpha) / \Omega R$
LAMB	λ	inflow ratio, $-\mu (\tan\alpha) + 0.5\, C_T{}^*/(\lambda^2 + \mu^2)^{\frac{1}{2}}$
CZ	C_N	normal-force coefficient, normal force/q_∞ S
CX	C_A	axial-force coefficient, axial force/q_∞ S
CPM	C_m	pitching-moment coefficient, pitching moment/qSc
CRM	C_ℓ	rolling-moment coefficient, rolling moment/q_∞sb
CL	C_L	lift coefficient, lift/q_∞ S

KEY TO ABBREVIATIONS - ROTOR TEST RESULTS (Cont'd)

CD	C_D	drag coefficient, drag/q_∞ S
CT	C_T	thrust coefficient, $\frac{1}{2} C_N (V_\infty/\Omega R)^2$
CH	C_H	in-plane force coefficient, $\frac{1}{2} C_A (V_\infty/\Omega R)^2$
CQ	C_q	torque coefficient, $10 \times \frac{1}{2} C_n (V_\infty/\Omega R)^2$
CLR	C_{L_R}	rotor lift coefficient, $\frac{1}{2} C_L (V_\infty/\Omega R)^2$
CDR	C_{D_R}	rotor drag coefficient, $\frac{1}{2} C_D (V_\infty/\Omega R)^2$
LOD	$(L/D)_R$	rotor lift-to-drag ratio, $C_{L_R} / \left[C_q (\Omega R/V_\infty) + C_{D_R}\right]$
DL	DL	disc loading, $C_L q_\infty$, lb/ft^2
CRB	$C_{\ell_{Bal}}$	balance axis rolling-moment coefficient, balance rolling-moment/q_∞ Sb

APPENDIX B. ROTOR TEST RESULTS
TARES - RUNS 37, 38

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
37	1	12	614	1	0626	1603	0.143	0.412	0888.	012.5	068.9	.0969	00.81	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	CZ	CX	CPM	CRM	CL	CD
296	00.02	-00.10	00.05	00.04	160.7	281.5	.0167	.0153	.0020	-.0005	.0166	.0153
297	00.01	-00.23	00.03	00.04	161.3	420.6	.0177	.0165	.0011	-.0007	.0176	.0165
298	00.07	-00.18	00.07	00.03	161.9	562.1	.0158	.0139	.0021	-.0008	.0158	.0139
299	00.17	-00.28	00.06	00.03	161.9	702.0	.0174	.0168	.0010	-.0010	.0174	.0168
300	-00.01	-00.04	00.04	05.01	162.0	278.1	.0247	.0135	.0048	-.0014	.0234	.0156
301	00.06	-00.05	00.07	05.01	162.0	419.7	.0226	.0130	.0045	-.0015	.0213	.0149
302	00.16	-00.15	00.06	05.00	162.0	560.5	.0211	.0098	.0054	-.0017	.0201	.0116
303	00.11	-00.25	00.07	05.00	162.0	700.4	.0204	.0110	.0053	-.0018	.0193	.0127
304	00.04	-00.18	00.06	10.05	161.6	279.8	.0310	.0090	.0061	-.0025	.0289	.0143
305	00.09	-00.15	00.06	10.03	161.6	418.9	.0288	.0074	.0070	-.0029	.0271	.0124
306	00.12	-00.12	00.08	10.05	161.6	562.1	.0304	.0068	.0074	-.0029	.0288	.0120
307	00.17	-00.24	00.07	10.03	162.1	699.5	.0278	.0092	.0070	-.0030	.0258	.0139
308	00.01	-00.03	00.06	10.06	162.1	000.0	.0330	.0101	.0068	-.0025	.0307	.0158
309	00.00	-00.13	00.07	05.06	161.7	000.0	.0334	.0120	.0075	-.0007	.0323	.0149
310	-00.01	-00.01	00.06	-00.00	162.1	000.0	.0254	.0197	.0003	.0001	.0254	.0197

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
38	1	12	614	1	0626	1620	0.286	0.798	0899.	048.7	076.5	.0938	00.79	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	CZ	CX	CPM	CRM	CL	CD
311	00.03	-00.11	00.07	-00.01	322.3	277.3	.0230	.0171	.0008	-.0001	.0230	.0171
312	00.05	-00.09	00.06	-00.01	322.9	416.4	.0222	.0179	.0007	-.0002	.0222	.0179
313	00.14	-00.21	00.07	-00.01	323.2	560.5	.0221	.0170	.0010	-.0003	.0221	.0170
314	00.12	-00.19	00.08	-00.01	323.2	697.0	.0220	.0173	.0008	-.0004	.0220	.0173
315	00.00	-00.13	00.03	02.49	323.1	278.1	.0255	.0171	.0012	-.0002	.0247	.0182
316	00.10	-00.07	00.06	02.50	323.4	416.4	.0250	.0171	.0012	-.0003	.0242	.0182
317	00.08	-00.17	00.06	02.49	323.0	561.3	.0245	.0161	.0015	-.0004	.0238	.0172
318	00.09	-00.13	00.08	02.49	323.1	700.4	.0236	.0163	.0015	-.0005	.0229	.0173
319	00.06	-00.06	00.06	05.01	322.9	280.6	.0269	.0158	.0018	-.0003	.0255	.0181
320	00.18	-00.13	00.06	04.99	323.2	419.7	.0268	.0171	.0018	-.0004	.0252	.0193
321	00.12	-00.01	00.08	05.00	322.9	560.5	.0276	.0148	.0021	-.0005	.0262	.0171
322	00.12	-00.22	00.06	05.00	322.9	700.4	.0263	.0152	.0020	-.0006	.0249	.0175
323	00.06	-00.01	00.06	07.47	322.7	279.8	.0283	.0150	.0028	-.0005	.0261	.0185
324	00.11	-00.12	00.07	07.47	323.0	416.4	.0289	.0151	.0024	-.0006	.0267	.0188
325	00.12	-00.09	00.07	07.47	323.5	558.8	.0288	.0140	.0028	-.0007	.0268	.0176
326	00.11	-00.21	00.09	07.48	323.4	698.7	.0290	.0147	.0024	-.0008	.0269	.0183
327	00.02	-00.06	00.08	09.98	323.4	277.3	.0315	.0132	.0029	-.0006	.0287	.0185
328	00.04	-00.01	00.08	09.97	323.2	422.2	.0316	.0150	.0027	-.0008	.0295	.0203
329	00.13	-00.04	00.07	09.98	323.2	561.3	.0315	.0129	.0032	-.0009	.0288	.0182
330	00.13	-00.23	00.07	09.98	323.2	698.7	.0314	.0134	.0030	-.0010	.0286	.0187

APPENDIX B. ROTOR TEST RESULTS (Continued)
TARES - RUNS 39, 40

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
39	1	12	614	1	0626	1639	0.433	1.133	0918.	106.0	085.4	.0895	00.75	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	CZ	CX	CPM	CRM	CL	CD
331	00.00	-00.03	00.02	-00.03	486.6	282.3	.0231	.0174	.0007	-.0001	.0231	.0174
332	00.07	-00.10	00.07	-00.03	487.1	420.6	.0230	.0181	.0006	-.0001	.0230	.0181
333	00.13	-00.11	00.07	-00.03	487.0	561.3	.0234	.0178	.0006	-.0002	.0234	.0178
334	00.08	-00.20	00.08	-00.03	487.6	700.4	.0231	.0178	.0006	-.0002	.0232	.0178
335	00.01	-00.13	00.04	02.52	486.9	280.6	.0250	.0173	.0010	-.0001	.0242	.0183
336	00.10	-00.05	00.07	02.53	488.0	419.7	.0250	.0173	.0010	-.0002	.0243	.0184
337	00.10	-00.17	00.08	02.53	486.9	561.3	.0254	.0173	.0010	-.0002	.0246	.0184
338	00.20	-00.16	00.09	02.53	487.4	697.0	.0254	.0171	.0010	-.0003	.0246	.0182
339	00.10	-00.06	00.06	04.96	485.7	279.0	.0271	.0167	.0015	-.0002	.0255	.0190
340	00.13	-00.10	00.08	04.95	485.7	429.8	.0280	.0168	.0013	-.0002	.0265	.0192
341	00.10	-00.04	00.06	04.96	487.6	559.6	.0280	.0169	.0014	-.0003	.0264	.0192
342	00.13	-00.14	00.08	04.96	488.3	697.9	.0272	.0164	.0015	-.0003	.0256	.0187
343	00.01	-00.09	00.06	07.47	488.2	276.5	.0296	.0160	.0018	-.0002	.0272	.0197
344	00.12	-00.14	00.08	07.48	491.0	417.2	.0298	.0159	.0017	-.0003	.0275	.0196
345	00.06	-00.04	00.08	07.47	490.2	562.1	.0298	.0156	.0018	-.0004	.0275	.0194
346	00.13	-00.11	00.08	07.48	489.8	697.9	.0297	.0157	.0018	-.0004	.0274	.0195
347	00.07	-00.16	00.06	09.92	489.7	281.5	.0316	.0145	.0022	-.0004	.0286	.0197
348	00.07	-00.21	00.08	09.92	489.4	439.0	.0311	.0143	.0022	-.0004	.0282	.0195
349	00.10	-00.17	00.08	09.92	489.5	561.3	.0308	.0143	.0023	-.0005	.0279	.0194
350	00.15	-00.20	00.09	09.93	489.2	697.0	.0316	.0144	.0022	-.0005	.0287	.0197

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
40	1	12	614	1	0626	1658	0.508	1.306	0940.	142.2	097.5	.0867	00.73	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	CZ	CX	CPM	CRM	CL	CD
351	-00.07	00.14	00.03	00.01	572.7	286.5	.0230	.0176	.0008	-.0001	.0230	.0176
352	00.02	00.14	00.04	00.01	572.8	418.0	.0232	.0179	.0007	-.0001	.0232	.0179
353	00.00	00.10	00.04	00.02	572.7	561.3	.0236	.0178	.0007	-.0002	.0236	.0178
354	-00.01	00.05	00.03	00.01	573.2	699.5	.0233	.0178	.0007	-.0002	.0233	.0178
355	-00.02	00.26	00.06	02.53	574.3	282.3	.0258	.0177	.0008	-.0001	.0250	.0188
356	00.00	00.21	00.07	02.53	574.0	423.9	.0254	.0176	.0009	-.0001	.0246	.0187
357	-00.00	00.20	00.04	02.53	574.7	559.6	.0256	.0174	.0010	-.0002	.0248	.0185
358	00.00	00.10	00.02	02.53	575.4	702.9	.0261	.0176	.0009	-.0002	.0253	.0187
359	-00.08	00.14	00.02	05.03	574.4	289.0	.0275	.0167	.0014	-.0002	.0259	.0191
360	00.00	00.20	00.04	05.04	576.0	428.9	.0278	.0169	.0013	-.0002	.0262	.0193
361	-00.03	00.07	00.01	05.04	575.9	561.3	.0280	.0168	.0013	-.0002	.0265	.0192
362	00.01	00.02	00.03	05.02	575.7	698.7	.0278	.0169	.0013	-.0003	.0262	.0192
363	-00.04	00.12	00.03	07.46	576.1	290.7	.0296	.0159	.0017	-.0002	.0273	.0196
364	-00.01	00.08	00.04	07.47	575.9	420.6	.0297	.0162	.0015	-.0003	.0274	.0199
365	00.01	00.18	00.04	07.46	575.8	562.1	.0300	.0161	.0016	-.0003	.0277	.0199
366	00.02	-00.02	00.04	07.46	576.0	702.0	.0299	.0161	.0016	-.0004	.0275	.0198
367	-00.04	00.15	00.02	09.97	574.0	284.0	.0314	.0152	.0020	-.0003	.0283	.0204
368	00.00	00.12	00.04	09.98	574.7	439.6	.0309	.0151	.0019	-.0004	.0278	.0203
369	00.02	00.10	00.06	09.99	575.7	562.1	.0310	.0150	.0020	-.0004	.0279	.0202
370	00.04	-00.02	00.04	09.99	574.8	701.2	.0312	.0153	.0019	-.0004	.0281	.0204

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 29, 30, 31, 32

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
29	1	12	014	1	0621	1001	0.292	0.776	0845.	047.5	069.1	.0893	00.75	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
233	-00.05	-01.57	03.81	05.00	326.3	697.9	0.466	-.0343	.0550	.0028	.0016
234	02.04	-01.37	05.16	05.05	327.6	697.9	0.468	-.0329	.0719	.0013	.0044
235	-02.12	-01.09	02.21	04.93	322.5	703.7	0.457	-.0355	.0345	.0037	.0028

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
30	1	12	014	1	0621	1007	0.287	0.762	0847.	046.0	071.4	.0893	00.75	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
237	00.00	-01.49	02.57	-00.05	321.2	697.9	0.460	.0029	.0219	.0035	-.0002
238	01.94	-02.33	03.92	00.21	321.0	699.5	0.459	.0033	.0434	.0027	-.0036
239	-02.10	-01.91	01.13	00.05	320.4	701.2	0.457	-.0009	-.0038	.0035	-.0040

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
31	1	12	014	1	0621	1010	0.358	0.934	0858.	070.5	076.4	.0875	00.73	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
240	-00.10	-02.34	02.82	-00.05	401.3	626.6	0.640	.0014	.0050	.0030	-.0030
241	01.96	-02.37	04.27	-00.03	401.2	628.3	0.639	.0021	.0109	.0031	-.0014
242	04.03	-02.44	05.9	-00.01	401.9	630.0	0.638	.0029	.0177	.0030	-.0008
243	06.05	-02.79	07.53	00.01	401.9	630.0	0.638	.0036	.0235	.0028	-.0012
244	05.71	00.96	06.27	00.04	402.4	633.3	0.635	.0048	.0394	.0040	.0114
245	05.69	04.02	05.35	00.07	403.0	630.0	0.640	.0060	.0426	.0046	.0218
246	05.86	08.79	04.46	00.07	401.9	630.0	0.637	.0057	.0403	.0166	.0346
247	-00.41	02.65	00.99	-00.02	403.7	630.0	0.641	.0026	.0150	.0041	.0139
248	00.05	05.66	-00.04	00.02	403.7	630.0	0.641	.0040	.0259	.0054	.0243

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
32	1	12	014	1	0621	1037	0.358	0.931	0869.	071.4	083.4	.0875	00.73	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
249	-00.04	-02.49	04.56	05.10	404.0	627.5	0.641	-.0535	.0229	.0028	-.0012
250	02.90	-02.46	06.64	05.13	404.3	628.3	0.641	-.0523	.0330	.0021	.0004
251	06.03	01.90	07.64	05.22	403.0	627.5	0.640	-.0484	.0621	.0030	.0179
252	-03.13	-01.60	01.93	05.06	404.9	626.6	0.644	-.0545	.0152	.0035	.0007
253	-03.15	03.71	00.18	05.11	404.0	629.2	0.640	-.0523	.0304	.0050	.0184
254	-02.99	-04.99	02.66	05.05	403.9	622.5	0.646	-.0558	.0078	.0036	-.0110
255	-02.84	-08.61	03.85	05.01	404.6	623.3	0.647	-.0568	-.0013	.0032	-.0243

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
.0001	.0545	.0076	.0060	.0003	.0014	.0060	.0008	05.31	02.59	.0001	233
.0005	.0715	.0076	.0079	.0001	.0020	.0079	.0008	06.27	03.43	.0005	234
.0001	.0341	.0066	.0036	.0004	.0017	.0036	.0007	03.35	01.58	.0001	235

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
.0002	.0219	.0035	.0023	.0004	.0032	.0023	.0004	02.18	01.01	.0002	237
.0001	.0434	.0028	.0046	.0003	.0034	.0046	.0003	04.43	01.99	.0001	238
.0001	-.0038	.0035	-.0004	.0004	.0040	-.0004	.0004	-00.32	-00.18	.0001	239

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
.0001	.0050	.0030	.0010	.0006	.0063	.0010	.0006	00.64	00.35	.0001	240
.0001	.0109	.0031	.0022	.0006	.0052	.0022	.0006	01.53	00.77	.0001	241
.0001	.0177	.0030	.0036	.0006	.0070	.0036	.0006	02.12	01.25	.0001	242
.0002	.0235	.0028	.0048	.0006	.0085	.0048	.0006	02.51	01.66	.0002	243
.0001	.0334	.0041	.0067	.0008	.0048	.0067	.0008	04.25	02.36	.0001	244
.0002	.0426	.0047	.0087	.0009	.0063	.0087	.0010	04.50	03.03	.0002	245
.0004	.0403	.0166	.0082	.0034	.0118	.0082	.0034	01.57	02.85	.0004	246
.0001	.0150	.0041	.0031	.0008	.0024	.0031	.0008	02.52	01.07	.0001	247
.0002	.0259	.0054	.0053	.0011	.0022	.0053	.0011	03.65	01.85	.0002	248

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
.0001	.0226	.0049	.0047	.0006	.0170	.0047	.0010	01.28	01.61	.0001	249
.0002	.0327	.0050	.0068	.0004	.0078	.0068	.0010	03.01	02.34	.0002	250
.0005	.0615	.0087	.0128	.0006	.0074	.0127	.0018	04.32	04.38	.0005	251
.0001	.0148	.0048	.0032	.0007	.0063	.0031	.0010	01.56	01.06	.0001	252
.0001	.0298	.0076	.0063	.0010	-.0004	.0061	.0016	04.07	02.13	.0001	253
.0000	.0075	.0043	.0017	.0008	.0064	.0016	.0009	00.83	00.53	.0000	254
.0004	-.0015	.0031	-.0003	.0007	.0128	-.0003	.0007	-00.12	-00.11	.0004	255

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 35, 36, 41

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
35	1	12	614	1	0621	1248	0.433	1.108	0898.	103.7	093.2	.0863	00.72	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
276	-00.01	00.12	01.95	-00.07	490.0	559.6	0.876	.0026	.0067	.0012	.0034
277	02.11	-00.53	03.72	-00.07	489.9	557.9	0.878	.0026	.0068	.0017	.0036
278	03.90	-00.20	05.20	-00.06	490.3	561.3	0.874	.0028	.0084	.0021	.0046
279	-02.01	00.10	00.11	-00.08	491.1	562.1	0.874	.0021	.0041	.0014	.0039
280	02.94	08.94	01.95	-00.03	492.0	559.6	0.879	.0049	.0203	.0035	.0253
281	-02.99	-00.02	-01.02	-00.09	493.5	565.5	0.873	.0018	.0023	.0012	.0041

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
36	1	12	614	1	0621	1313	0.434	1.105	0907.	105.1	099.5	.0862	00.72	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
282	-00.09	-02.13	04.40	05.00	493.9	563.0	0.874	-.0736	.0130	.0004	.0017
283	00.02	-05.08	05.04	04.99	493.3	562.1	0.874	-.0740	.0105	.0005	-.0059
284	00.06	03.94	02.71	05.07	492.7	563.8	0.870	-.0708	.0294	.0015	.0145
285	-02.07	-01.77	02.62	05.01	492.8	562.1	0.873	-.0798	.0125	.0005	.0015
286	-02.18	05.62	00.54	05.06	492.3	559.6	0.876	-.0720	.0253	.0004	.0187
287	-02.00	-06.29	03.61	04.94	493.0	563.8	0.871	-.0762	-.0040	.0013	-.0070

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
41	1	12	614	1	0626	2206	0.434	1.129	0883.	102.1	078.1	.0872	00.73	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
379	00.08	-02.37	02.28	-00.12	483.9	490.1	0.987	.0035	.0060	.0014	.0006
380	-01.94	-02.32	00.55	-00.12	484.5	490.9	0.987	.0033	.0048	.0015	.0004
381	-03.99	-02.28	-01.62	-00.11	484.8	490.9	0.988	.0034	.0058	.0017	.0005
382	01.85	-01.90	03.72	-00.11	485.9	490.1	0.991	.0035	.0061	.0014	.0018
383	04.13	-01.93	05.82	-00.11	485.1	489.3	0.991	.0034	.0058	.0026	.0020
384	-04.00	-03.79	01.06	04.89	486.1	489.3	0.990	-.0812	.0140	.0009	-.0010
385	03.88	-03.85	07.69	04.90	487.0	490.9	0.988	-.0809	.0153	.0012	.0009
386	-00.03	-03.98	04.65	04.89	487.0	491.8	0.987	-.0808	.0149	.0015	-.0007
387	-00.04	-04.00	05.61	07.48	487.7	494.3	0.978	-.1231	.0218	.0001	.0009
388	-03.98	-04.06	02.26	07.49	487.6	491.8	0.983	-.1242	.0206	.0005	-.0001
389	02.96	-05.03	09.32	07.48	487.9	490.1	0.987	-.1244	.0212	.0003	-.0004
390	00.07	-04.79	06.94	09.96	488.7	491.8	0.979	-.1647	.0289	-.0004	.0006
391	-03.93	-04.49	03.49	09.96	487.8	490.9	0.979	-.1650	.0274	.0015	-.0002

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
.0000	.0067	.0012	.0026	.0005	.0044	.0026	.0004	02.68	00.69	.0000	276
.0000	.0068	.0017	.0026	.0006	.0064	.0026	.0006	01.92	00.70	-.0000	277
-.0001	.0084	.0021	.0032	.0008	.0038	.0032	.0008	02.58	00.87	-.0001	278
-.0000	.0041	.0014	.0016	.0005	.0108	.0016	.0005	00.89	00.43	-.0000	279
-.0002	.0203	.0035	.0078	.0014	.0100	.0078	.0014	03.13	02.11	-.0002	280
.0001	.0023	.0011	.0009	.0004	.0064	.0009	.0004	00.75	00.24	.0001	281

CRM	CL	CD	CT	CH	CG	CLR	CDR	LOD	DL	CRB	CORR
.0000	.0129	.0016	.0050	.0002	.0050	.0050	.0006	04.24	01.36	.0000	282
.0001	.0104	.0014	.0040	.0002	.0252	.0040	.0005	01.17	01.09	.0001	283
.0001	.0292	.0041	.0112	.0006	-.0003	.0111	.0016	07.28	03.05	.0001	284
-.0000	.0124	.0016	.0048	.0002	.0041	.0047	.0006	04.35	01.29	-.0000	285
.0000	.0252	.0026	.0098	.0002	-.0005	.0097	.0010	10.22	02.63	.0000	286
.0000	-.0041	.0009	-.0015	.0005	.0094	-.0016	.0004	-01.08	-00.43	.0000	287

CRM	CL	CD	CT	CH	CG	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0060	.0014	.0029	.0007	.0037	.0029	.0007	02.71	00.61	-.0004	379
-.0005	.0048	.0014	.0023	.0007	.0043	.0028	.0007	02.04	00.49	-.0005	380
-.0003	.0088	.0017	.0029	.0008	.0047	.0029	.0008	02.20	00.60	-.0003	381
-.0005	.0061	.0014	.0030	.0007	.0031	.0030	.0007	03.05	00.63	-.0005	382
-.0005	.0058	.0025	.0028	.0013	.0025	.0026	.0013	01.89	00.59	-.0005	383
-.0005	.0139	.0021	.0069	.0005	.0021	.0069	.0010	05.48	01.43	-.0005	384
-.0006	.0152	.0025	.0075	.0006	.0021	.0075	.0012	05.17	01.56	-.0006	385
-.0005	.0147	.0027	.0073	.0007	.0022	.0072	.0013	04.63	01.52	-.0005	386
-.0005	.0216	.0030	.0106	.0001	-.0007	.0105	.0014	07.65	02.23	-.0005	387
-.0006	.0204	.0032	.0101	.0003	-.0017	.0100	.0016	07.10	02.11	-.0006	388
-.0006	.0210	.0031	.0105	.0002	.0029	.0104	.0015	05.73	02.17	-.0006	389
-.0007	.0285	.0046	.0142	-.0002	-.0022	.0141	.0023	06.79	02.96	-.0007	390
-.0006	.0267	.0063	.0135	.0008	-.0052	.0132	.0031	05.15	02.77	-.0006	391

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 42, 43

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	G	TT	RHO	GAMA	PHI	DELS
42	1	12	614	1	0627	0854	0.432	1.090	0858.	098.7	079.9	.0845	00.71	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
397	00.03	-02.15	02.03	-00.12	483.1	419.7	1.151	.0040	.0053	.0014	.0009
398	02.06	-02.70	04.05	-00.13	482.7	419.7	1.150	.0035	.0033	.0016	.0007
399	04.01	-03.15	06.05	-00.15	483.2	418.0	1.156	.0031	.0007	.0019	.0003
400	-02.06	-01.82	-00.11	-00.11	483.4	420.6	1.149	.0045	.0077	.0014	.0012
401	-04.04	-01.84	-02.22	-00.11	484.8	423.1	1.146	.0048	.0091	.0017	.0015
402	-00.05	-02.51	00.89	-02.53	485.6	419.7	1.156	.0506	-.0013	.0015	-.0006
403	02.00	-02.98	03.14	-02.54	485.8	420.6	1.154	.0501	-.0039	.0018	-.0010
404	01.96	-01.74	02.77	-02.53	485.9	421.4	1.152	.0503	-.0019	.0016	.0007
405	03.87	-02.01	04.82	-02.54	486.0	418.0	1.161	.0503	-.0040	.0024	.0005
406	-01.99	-00.64	-02.04	-02.51	485.2	421.4	1.150	.0517	.0047	.0014	.0028
407	-01.88	-02.38	-01.27	-02.52	484.6	417.2	1.160	.0514	.0012	.0014	.0001
408	-04.02	-00.89	-03.94	-02.50	487.4	420.6	1.158	.0523	.0058	.0018	.0022
409	-00.05	-03.84	04.36	04.98	488.6	419.7	1.160	-.0961	.0169	.0006	.0007
410	01.95	-04.20	06.39	04.96	486.1	420.6	1.151	-.0955	.0154	.0008	.0003
411	04.04	-04.38	08.34	04.96	488.8	420.6	1.158	-.0967	.0133	.0010	.0005
412	-02.03	-03.29	02.60	04.97	489.2	425.6	1.145	-.0944	.0183	.0009	.0010
413	-04.05	-03.05	00.56	04.96	489.2	419.7	1.161	-.0953	.0189	.0013	.0010
414	00.01	-05.57	05.92	07.44	488.9	417.2	1.162	-.1455	.0210	.0005	-.0008
415	01.96	-05.90	07.68	07.44	488.4	420.6	1.151	-.1446	.0198	.0006	-.0010
416	-02.03	-03.91	03.86	07.45	489.2	446.5	1.086	-.1354	.0242	.0009	.0017
417	-04.07	-03.47	01.94	07.45	489.6	421.4	1.152	-.1434	.0248	.0015	.0016
418	00.01	-04.71	05.80	07.45	489.3	416.4	1.165	-.1457	.0227	-.0003	.0007
419	-00.02	-05.24	07.01	10.02	488.5	419.7	1.146	-.1935	.0308	.0007	.0008
420	-02.10	-05.13	05.32	10.02	488.9	423.9	1.136	-.1919	.0302	.0005	.0007
421	-04.09	-05.30	03.44	10.02	488.9	426.4	1.129	-.1910	.0294	.0000	.0005
422	-06.14	-05.15	01.41	10.01	489.6	423.9	1.137	-.1924	.0287	.0001	.0005
423	-00.05	-06.11	07.14	10.01	490.1	424.7	1.136	-.1924	.0286	-.0014	-.0000

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	G	TT	RHO	GAMA	PHI	DELS
43	1	12	614	1	0627	0940	0.434	1.088	0861.	102.1	093.5	.0846	00.71	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
424	00.08	-04.07	02.11	-00.07	491.1	350.2	1.403	.0036	.0052	.0022	-.0007
425	-02.05	-03.36	-00.58	-00.05	489.2	350.2	1.397	.0051	.0111	.0020	.0004
426	-04.09	-03.05	-03.15	-00.04	490.8	346.8	1.415	.0065	.0155	.0025	.0014
427	02.03	-03.98	04.35	-00.09	491.7	350.2	1.404	.0027	.0015	.0024	-.0006
428	04.02	-04.20	06.98	-00.10	491.7	362.7	1.356	.0012	-.0035	.0031	-.0012
429	00.00	-05.41	04.32	05.02	491.0	350.2	1.397	-.1162	.0184	.0007	-.0003
430	02.02	-05.85	06.56	05.01	491.4	351.0	1.394	-.1171	.0149	.0010	-.0006
431	03.98	-06.37	08.79	05.00	491.4	346.8	1.412	-.1201	.0097	.0018	-.0015
432	-02.02	-05.26	02.50	05.03	490.8	351.9	1.389	-.1153	.0203	.0010	-.0000
433	-04.02	-04.94	00.32	05.03	491.2	351.0	1.394	-.1150	.0219	.0017	.0004
434	-06.10	-05.07	-01.99	05.04	490.2	349.3	1.398	-.1145	.0247	.0030	.0004
435	00.03	-06.05	05.70	07.46	490.8	349.3	1.393	-.1741	.0237	.0003	.0001
436	01.88	-06.67	07.54	07.46	491.6	346.8	1.405	-.1763	.0214	-.0001	-.0003
437	03.62	-06.64	09.26	07.46	490.9	351.9	1.383	-.1744	.0191	.0004	-.0004
438	-02.01	-06.73	03.81	07.47	490.6	351.9	1.382	-.1729	.0242	.0005	-.0007
439	-04.03	-06.93	01.87	07.47	490.5	347.7	1.399	-.1744	.0256	.0014	-.0008
440	-06.14	-06.59	-00.34	07.47	491.3	351.0	1.388	-.1727	.0266	.0027	-.0002
441	-00.07	-07.67	07.04	09.93	490.9	346.8	1.394	-.2338	.0287	-.0005	-.0003
442	02.07	-07.93	08.92	09.92	491.1	351.9	1.375	-.2309	.0275	-.0002	-.0008
443	-02.02	-07.58	05.27	09.94	490.9	346.8	1.394	-.2334	.0308	.0014	-.0008
444	-04.13	-07.29	03.09	09.93	490.3	355.2	1.359	-.2272	.0315	.0015	-.0004
445	-06.02	-06.97	00.85	09.94	490.3	349.3	1.382	-.2306	.0329	.0038	.0001

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0053	.0014	.0035	.0009	.0030	.0035	.0009	03.00	00.53	-.0004	397
-.0004	.0033	.0016	.0022	.0011	.0033	.0022	.0011	01.62	00.33	-.0004	398
-.0004	.0007	.0019	.0004	.0013	.0034	.0004	.0013	00.28	00.07	-.0004	399
-.0005	.0077	.0013	.0051	.0009	.0033	.0051	.0009	04.35	00.76	-.0005	400
-.0005	.0091	.0017	.0060	.0011	.0031	.0060	.0011	04.38	00.90	-.0005	401
-.0003	-.0013	.0016	-.0009	.0010	.0051	-.0009	.0011	-00.57	-00.13	-.0003	402
-.0003	-.0038	.0019	-.0026	.0012	.0047	-.0025	.0013	-01.48	-00.38	-.0003	403
-.0004	-.0018	.0017	-.0013	.0011	.0040	-.0012	.0011	-00.81	-00.18	-.0004	404
-.0004	-.0039	.0026	-.0027	.0016	.0030	-.0026	.0017	-01.31	-00.38	-.0004	405
-.0005	.0047	.0012	.0031	.0009	.0035	.0031	.0008	02.95	00.47	-.0005	406
-.0004	.0012	.0014	.0008	.0010	.0052	.0008	.0009	00.60	00.12	-.0004	407
-.0005	.0059	.0015	.0039	.0012	.0044	.0039	.0010	02.85	00.59	-.0005	408
-.0007	.0168	.0021	.0115	.0004	.0010	.0114	.0014	07.53	01.69	-.0007	409
-.0006	.0152	.0021	.0103	.0005	.0020	.0102	.0014	06.48	01.52	-.0006	410
-.0005	.0131	.0022	.0090	.0007	.0026	.0089	.0015	05.27	01.32	-.0005	411
-.0006	.0161	.0024	.0121	.0006	-.0007	.0120	.0016	07.70	01.83	-.0006	412
-.0006	.0187	.0029	.0129	.0009	-.0025	.0127	.0020	07.17	01.89	-.0006	413
-.0006	.0208	.0032	.0144	.0003	.0005	.0143	.0022	06.32	02.10	-.0006	414
-.0005	.0196	.0032	.0134	.0004	.0020	.0132	.0021	05.73	01.98	-.0005	415
-.0006	.0239	.0040	.0145	.0005	-.0050	.0144	.0024	07.42	02.42	-.0006	416
-.0006	.0244	.0047	.0168	.0010	-.0072	.0165	.0032	06.43	02.48	-.0006	417
-.0006	.0226	.0026	.0157	-.0002	-.0009	.0156	.0018	09.03	02.28	-.0006	418
-.0007	.0302	.0061	.0208	.0005	-.0050	.0204	.0041	05.56	03.04	-.0007	419
-.0006	.0296	.0058	.0201	.0004	-.0075	.0197	.0038	06.17	03.00	-.0006	420
-.0006	.0289	.0051	.0193	.0000	-.0096	.0190	.0034	07.51	02.92	-.0006	421
-.0005	.0282	.0051	.0191	.0001	-.0128	.0188	.0034	08.28	02.86	-.0005	422
-.0006	.0284	.0036	.0191	-.0009	-.0037	.0189	.0024	09.11	02.89	-.0006	423

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0052	.0022	.0051	.0022	.0038	.0051	.0022	02.09	00.59	-.0004	424
-.0005	.0111	.0020	.0109	.0020	.0037	.0109	.0020	04.90	01.13	-.0005	425
-.0006	.0155	.0024	.0155	.0025	.0010	.0155	.0025	06.14	01.58	-.0006	426
-.0004	.0015	.0024	.0015	.0024	.0045	.0015	.0024	00.54	00.15	-.0004	427
-.0003	-.0035	.0031	-.0032	.0028	.0037	-.0032	.0028	-01.04	-00.36	-.0003	428
-.0005	.0182	.0023	.0180	.0007	.0012	.0179	.0023	07.50	01.86	-.0005	429
-.0005	.0147	.0023	.0146	.0009	.0036	.0144	.0022	05.87	01.51	-.0005	430
-.0004	.0095	.0026	.0097	.0018	.0049	.0096	.0026	03.23	00.97	-.0004	431
-.0005	.0201	.0028	.0197	.0010	-.0016	.0196	.0027	07.64	02.05	-.0005	432
-.0004	.0216	.0036	.0214	.0017	-.0075	.0212	.0035	07.06	02.21	-.0004	433
-.0006	.0243	.0052	.0243	.0030	-.0135	.0240	.0051	05.81	02.48	-.0006	434
-.0006	.0235	.0033	.0234	.0003	-.0022	.0232	.0033	07.37	02.40	-.0006	435
-.0006	.0212	.0027	.0215	-.0001	.0015	.0213	.0027	07.67	02.17	-.0006	436
-.0006	.0189	.0029	.0186	.0004	.0032	.0184	.0028	05.98	01.93	-.0006	437
-.0007	.0239	.0037	.0235	.0005	-.0044	.0232	.0036	07.11	02.44	-.0007	438
-.0007	.0252	.0047	.0255	.0014	-.0095	.0251	.0047	06.24	02.57	-.0007	439
-.0005	.0260	.0061	.0260	.0026	-.0166	.0255	.0060	05.31	02.66	-.0005	440
-.0006	.0283	.0044	.0287	-.0005	-.0050	.0284	.0044	06.97	02.90	-.0006	441
-.0007	.0271	.0046	.0268	-.0002	.0004	.0264	.0044	05.91	02.77	-.0007	442
-.0006	.0301	.0067	.0308	.0014	-.0108	.0301	.0067	05.10	03.07	-.0006	443
-.0005	.0308	.0069	.0300	.0014	-.0171	.0293	.0066	05.47	03.14	-.0005	444
-.0007	.0318	.0094	.0324	.0038	-.0260	.0313	.0093	04.21	03.24	-.0007	445

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 44, 45

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
44	1	12	614	1	0527	1048	0.434	1.097	0888.	102.7	093.0	.0853	00.72	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
446	00.10	-06.28	00.63	-00.00	490.6	213.6	2.297	.0097	.0168	-.0021	.0015
447	00.03	-04.47	01.89	00.08	490.1	282.3	1.736	.0012	.0082	-.0006	.0002
448	-02.05	-04.73	-00.91	00.10	490.6	282.3	1.738	.0034	.0148	-.0014	.0008
449	-02.05	-06.56	-00.57	00.09	489.8	279.8	1.750	.0022	.0110	-.0019	-.0008
450	-04.13	-06.10	-03.98	00.11	491.2	283.2	1.735	.0050	.0194	.0008	.0005
451	01.36	-05.43	03.84	00.05	490.8	281.5	1.743	-.0016	-.0004	.0011	-.0011
452	01.39	-03.16	03.83	00.07	492.6	284.8	1.730	-.0008	.0031	.0009	.0006
453	00.23	-07.24	04.50	04.98	491.8	284.8	1.720	-.1415	.0196	-.0009	-.0001
454	-02.03	-07.01	01.90	05.00	491.8	281.5	1.741	-.1417	.0240	-.0009	.0003
455	-03.97	-06.74	-00.33	05.01	492.3	280.6	1.747	-.1412	.0271	.0001	.0014
456	-06.21	-06.78	-03.23	05.02	492.5	284.0	1.727	-.1384	.0309	.0019	.0021
457	-00.15	-06.69	04.92	07.54	493.0	284.8	1.716	-.2136	.0312	-.0006	.0023
458	00.02	-06.79	05.94	07.53	494.8	283.2	1.732	-.2170	.0271	-.0002	.0009
459	-00.17	-06.61	04.92	07.53	494.1	285.7	1.715	-.2133	.0308	.0006	.0019
460	-02.18	-08.22	03.06	07.54	494.4	267.2	1.834	-.2282	.0315	.0011	.0008
461	-04.08	-07.96	00.71	07.56	494.0	278.1	1.761	-.2184	.0344	.0022	.0019
462	-06.16	-07.48	-01.71	07.57	493.4	274.8	1.780	-.2202	.0363	.0031	.0028
463	-06.50	-08.41	-02.14	07.56	493.6	283.2	1.728	-.2142	.0348	.0029	.0017
464	01.47	-09.16	07.92	10.06	493.2	277.3	1.751	-.2961	.0327	-.0017	.0011
465	-00.04	-08.76	06.21	10.06	493.5	268.9	1.807	-.3041	.0360	-.0018	.0018
466	00.15	-08.97	06.86	10.05	494.7	272.3	1.789	-.3021	.0330	-.0020	.0013
467	00.50	-08.82	06.97	10.06	495.2	271.4	1.796	-.3029	.0342	-.0025	.0018
468	-02.09	-09.25	03.92	10.08	494.5	274.8	1.772	-.2973	.0392	.0008	.0024
469	-02.04	-09.54	04.13	10.07	494.4	272.3	1.788	-.3010	.0360	.0007	.0011
470	-04.05	-09.29	01.94	10.07	494.2	272.3	1.787	-.2997	.0388	.0025	.0017
471	-00.00	-02.86	-00.03	-02.51	494.5	274.8	1.798	.0807	.0040	.0000	.0009
472	-03.89	-04.10	-05.86	-02.47	494.7	273.9	1.804	.0857	.0178	.0003	.0018
473	-02.02	-04.11	-03.15	-02.48	494.9	274.8	1.799	.0833	.0116	-.0006	.0011
474	01.98	-03.28	03.31	-02.55	495.1	273.9	1.806	.0768	-.0082	.0017	-.0004

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
45	1	12	614	1	0627	1258	0.507	1.260	0913.	137.9	100.2	.0838	00.70	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
475	00.93	-02.60	02.06	-00.03	573.6	501.8	1.143	.0029	.0078	.0018	.0000
476	04.30	-02.55	05.45	-00.04	575.0	498.5	1.154	.0021	.0042	.0026	.0000
477	-02.03	-02.14	-01.51	-00.01	574.1	493.4	1.164	.0039	.0127	.0016	.0015
478	-01.99	-02.24	-00.91	-00.02	574.6	490.9	1.170	.0034	.0100	.0019	.0008
479	-04.08	-01.56	-03.33	-00.01	574.4	495.1	1.160	.0040	.0133	.0023	.0017
480	-06.05	-01.98	-05.57	-00.01	574.5	496.0	1.158	.0042	.0142	.0034	.0014
481	-00.01	-03.29	03.55	04.95	576.9	493.4	1.165	-.0953	.0193	.0012	.0010
482	02.06	-02.94	05.37	04.96	576.7	496.0	1.158	-.0949	.0193	.0010	.0019
483	-02.10	-03.13	01.80	04.96	576.3	493.4	1.164	-.0952	.0198	.0015	.0009
484	-04.10	-02.71	-00.36	04.97	576.6	496.8	1.156	-.0946	.0204	.0029	.0016
485	-05.91	-02.44	-02.62	04.97	577.5	496.8	1.158	-.0941	.0224	.0045	.0021
486	-00.07	-03.89	04.85	07.53	578.9	497.6	1.153	-.1448	.0259	.0007	.0012
487	01.97	-04.17	06.62	07.53	578.4	511.0	1.122	-.1411	.0257	.0005	.0011
488	-02.04	-04.60	03.37	07.52	579.1	491.8	1.167	-.1470	.0240	.0015	.0002
489	-04.01	-04.16	01.24	07.53	578.6	496.0	1.157	-.1455	.0253	.0032	.0001
490	-05.95	-04.73	-00.65	07.52	578.5	490.1	1.170	-.1474	.0243	.0042	-.0007
491	-04.04	-05.30	00.23	07.53	578.6	490.9	1.169	-.1464	.0272	.0037	.0004
492	-01.92	-05.84	01.13	07.54	578.7	493.4	1.163	-.1448	.0319	.0020	.0019
493	-05.94	-04.26	-00.73	07.52	579.7	490.9	1.171	-.1473	.0241	.0049	.0002
494	00.00	-01.89	-00.26	-02.46	580.6	493.4	1.175	.0514	.0029	.0020	.0001
495	02.06	-02.11	02.05	-02.47	581.1	493.4	1.177	.0508	.0000	.0024	-.0005
496	03.92	-02.33	04.08	-02.48	581.2	493.4	1.177	.0502	-.0024	.0023	-.0010
497	-02.03	-01.97	-02.54	-02.45	580.5	491.8	1.179	.0522	.0057	.0018	.0004
498	-03.98	-02.03	-04.38	-02.45	580.2	491.8	1.179	.0525	.0071	.0026	-.0000
499	-04.11	-01.98	-04.64	-02.44	580.7	495.1	1.172	.0523	.0080	.0026	.0002
500	-05.95	-01.76	-06.73	-02.44	580.9	496.0	1.170	.0527	.0100	.0027	.0007
501	-00.01	-03.97	02.90	02.71	582.7	423.1	1.376	-.0601	.0147	.0009	.0003

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0006	.0168	-.0021	.0444	-.0055	-.0017	.0444	-.0055	-07.92	01.73	-.0006	446
-.0004	.0082	-.0006	.0124	-.0009	.0041	.0124	-.0009	-18.99	00.84	-.0004	447
-.0002	.0148	-.0014	.0224	-.0021	.0021	.0224	-.0021	-11.55	01.52	-.0002	448
-.0004	.0110	-.0019	.0169	-.0029	.0049	.0169	-.0029	-06.54	01.13	-.0004	449
-.0006	.0194	.0008	.0292	.0012	-.0063	.0292	.0013	32.74	02.00	-.0006	450
-.0004	-.0004	.0011	-.0007	.0017	.0055	-.0007	.0017	-00.33	-00.04	-.0004	451
.0000	.0031	.0009	.0046	.0013	.0023	.0046	.0013	03.25	00.32	.0000	452
-.0005	.0196	.0008	.0292	-.0013	.0010	.0292	.0012	22.71	02.02	-.0005	453
-.0005	.0240	.0012	.0366	-.0014	-.0090	.0366	.0018	29.08	02.48	-.0005	454
-.0006	.0270	.0025	.0417	.0002	-.0226	.0415	.0039	16.15	02.79	-.0006	455
-.0004	.0306	.0046	.0465	.0029	-.0421	.0461	.0070	10.13	03.17	-.0004	456
-.0007	.0310	.0035	.0468	-.0010	-.0159	.0465	.0052	10.88	03.22	-.0007	457
.0001	.0269	.0034	.0414	-.0003	-.0069	.0411	.0052	08.61	02.81	.0001	458
-.0006	.0305	.0046	.0461	.0009	-.0158	.0456	.0069	07.62	03.18	-.0006	459
-.0005	.0311	.0053	.0539	.0019	-.0268	.0532	.0090	07.04	03.24	-.0005	460
-.0006	.0338	.0067	.0542	.0035	-.0434	.0533	.0106	06.54	03.52	-.0006	461
-.0007	.0356	.0078	.0585	.0049	-.0621	.0573	.0126	06.28	03.70	-.0007	462
-.0006	.0342	.0075	.0529	.0044	-.0578	.0519	.0114	06.45	03.55	-.0006	463
-.0007	.0325	.0040	.0518	-.0027	-.0100	.0514	.0064	08.80	03.38	-.0007	464
-.0007	.0358	.0045	.0606	-.0030	-.0235	.0602	.0076	09.52	03.72	-.0007	465
-.0004	.0329	.0038	.0545	-.0032	-.0162	.0543	.0063	10.00	03.44	-.0004	466
-.0006	.0341	.0035	.0569	-.0041	-.0191	.0568	.0059	11.76	03.58	-.0006	467
-.0007	.0385	.0076	.0635	.0012	-.0429	.0623	.0123	06.26	04.02	-.0007	468
-.0007	.0353	.0070	.0593	.0012	-.0350	.0582	.0115	06.06	03.69	-.0007	469
-.0007	.0378	.0093	.0639	.0042	-.0553	.0622	.0153	05.09	03.94	-.0007	470
-.0004	.0040	-.0002	.0064	.0000	.0026	.0064	-.0003	-54.22	00.41	-.0004	471
-.0005	.0178	-.0005	.0290	.0005	-.0041	.0290	-.0008	-28.44	01.86	-.0005	472
-.0005	.0116	-.0011	.0188	-.0009	.0025	.0188	-.0017	-11.67	01.21	-.0005	473
-.0003	-.0081	.0020	-.0134	.0027	.0038	-.0132	.0033	-03.77	-00.85	-.0003	474

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0005	.0078	.0018	.0051	.0012	.0049	.0051	.0012	03.12	01.07	-.0005	475
-.0004	.0042	.0026	.0028	.0017	.0049	.0028	.0017	01.29	00.58	-.0004	476
-.0011	.0127	.0016	.0086	.0011	.0043	.0086	.0011	05.80	01.76	-.0011	477
-.0004	.0100	.0019	.0069	.0013	.0049	.0069	.0013	04.00	01.39	-.0004	478
-.0005	.0133	.0023	.0089	.0015	.0037	.0089	.0015	04.82	01.83	-.0005	479
-.0005	.0142	.0034	.0095	.0023	.0032	.0095	.0023	03.75	01.96	-.0005	480
-.0006	.0191	.0028	.0132	.0008	.0020	.0131	.0019	06.18	02.66	-.0006	481
-.0006	.0191	.0026	.0130	.0006	.0022	.0129	.0018	06.61	02.66	-.0006	482
-.0004	.0196	.0032	.0135	.0010	.0005	.0134	.0022	05.93	02.73	-.0004	483
-.0006	.0201	.0046	.0138	.0019	-.0025	.0136	.0031	04.68	02.80	-.0006	484
-.0006	.0219	.0064	.0151	.0030	-.0051	.0148	.0043	03.80	03.05	-.0006	485
-.0006	.0256	.0040	.0175	.0004	-.0009	.0173	.0027	06.52	03.58	-.0006	486
-.0006	.0254	.0038	.0164	.0003	.0009	.0163	.0025	06.44	03.55	-.0006	487
-.0006	.0236	.0046	.0166	.0010	-.0017	.0164	.0032	05.38	03.30	-.0006	488
-.0005	.0247	.0065	.0172	.0022	-.0040	.0168	.0044	04.14	03.45	-.0005	489
-.0005	.0235	.0074	.0169	.0030	-.0054	.0164	.0051	03.49	03.29	-.0005	490
-.0024	.0265	.0073	.0189	.0026	-.0076	.0184	.0050	04.19	03.70	-.0024	491
-.0043	.0313	.0062	.0219	.0014	-.0104	.0215	.0042	06.41	04.39	-.0043	492
-.0005	.0232	.0080	.0168	.0034	-.0063	.0162	.0056	03.20	03.26	-.0005	493
-.0003	.0030	.0019	.0020	.0014	.0065	.0021	.0013	01.13	00.42	-.0003	494
-.0003	.0001	.0024	.0000	.0017	.0062	.0001	.0017	00.04	00.02	-.0004	495
-.0003	-.0023	.0024	-.0017	.0016	.0058	-.0016	.0017	-00.74	-00.32	-.0003	496
-.0004	.0058	.0015	.0040	.0012	.0066	.0040	.0011	02.50	00.82	-.0004	497
-.0002	.0072	.0023	.0049	.0018	.0070	.0050	.0016	02.30	01.01	-.0002	498
-.0004	.0081	.0023	.0055	.0018	.0066	.0056	.0015	02.63	01.14	-.0004	499
-.0004	.0101	.0023	.0069	.0018	.0070	.0070	.0015	03.24	01.43	-.0004	500
-.0004	.0146	.0016	.0139	.0009	.0023	.0139	.0015	08.19	02.07	-.0004	501

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 46, 47, 48

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
46	1	12	514	1	0627	1334	0.509	1.252	0934.	141.6	114.1	.0836	00.70	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
502	00.00	-03.7[illegible]	01.63	-00.01	582.1	401.3	1.451	.0028	.0071	.0017	-.0006
503	01.92	-03.07	03.66	-00.03	582.8	399.6	1.458	.0020	.0037	.0018	-.0000
504	03.93	-03.55	05.92	-00.05	582.9	401.3	1.453	.0005	-.0019	.0027	-.0005
505	-01.89	-02.95	-00.62	00.01	582.4	399.6	1.457	.0045	.0131	.0016	.0007
506	-03.96	-04.11	-02.77	00.01	582.3	410.5	1.419	.0047	.0139	.0022	-.0006
507	-06.03	-03.98	-05.23	00.01	582.4	410.5	1.419	.0053	.0160	.0037	.0004
508	-00.09	-05.32	04.1[illegible]	04.97	582.6	417.2	1.391	-.1146	.0184	.0007	-.0004
509	01.96	-05.93	06.22	04.95	583.0	407.2	1.427	-.1184	.0144	.0009	-.0010
510	03.94	-06.06	08.3[illegible]	04.95	583.0	408.0	1.424	-.1197	.0104	.0017	-.0013
511	-02.00	-05.82	02.36	04.98	582.3	411.3	1.410	-.1163	.0189	.0009	-.0009
512	-04.04	-05.68	00.14	04.97	582.2	427.3	1.357	-.1108	.0215	.0019	-.0004
513	-06.14	-05.09	-02.29	04.99	583.5	413.0	1.407	-.1144	.0241	.0044	.0002
514	-04.95	-05.47	-00.61	04.99	584.2	426.1	1.360	-.1109	.0227	.0030	-.0004
515	-03.12	-06.21	02.56	07.48	584.1	423.1	1.369	-.1710	.0253	.0016	-.0003
516	-03.96	-06.08	01.5[illegible]	07.50	584.5	401.3	1.444	-.1800	.0278	.0025	-.0003
517	-02.08	-06.59	03.74	07.46	584.6	397.9	1.457	-.1820	.0250	.0006	-.0007
518	-00.03	-06.12	05.46	07.47	585.4	413.9	1.402	-.1754	.0244	-.0001	.0003
519	02.02	-06.45	07.5[illegible]	07.47	586.1	400.4	1.451	-.1821	.0222	.0000	-.0005

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
47	1	12	614	1	0627	1402	0.509	1.253	0942.	143.4	118.5	.0837	00.70	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
520	-00.05	-04.38	01.32	-00.01	585.4	35[illegible].2	1.672	.0042	.0094	.0013	-.0004
521	01.92	-03.73	03.8[illegible]	-00.02	584.7	352.7	1.658	.0019	.0029	.0015	-.0002
522	03.92	-04.39	06.53	-00.06	586.0	351.0	1.669	-.0008	-.0058	.0028	-.0011
523	-02.02	-04.84	-01.02	00.02	585.6	351.9	1.664	.0057	.0148	.0014	-.0006
524	-03.99	-04.14	-03.5[illegible]	00.03	585.1	351.0	1.667	.0074	.0200	.0023	.0005
525	-06.06	-03.97	-06.3[illegible]	00.05	584.2	346.0	1.688	.0090	.0246	.0046	.0017
526	-04.97	-04.20	-04.5[illegible]	00.04	584.5	354.4	1.650	.0079	.0221	.0031	.0010
527	-00.01	-05.52	04.[illegible]	04.97	584.5	351.9	1.655	-.1356	.0198	.0005	-.0004
528	02.08	-05.89	06.2[illegible]	04.96	585.0	348.5	1.672	-.1379	.0172	.0006	.0001
529	-02.04	-06.40	01.7[illegible]	05.00	585.1	348.5	1.673	-.1362	.0243	.0012	.0003
530	-04.03	-05.94	-00.34	04.99	585.1	373.6	1.560	-.1257	.0270	.0025	.0009
531	-06.03	-05.43	-02.81	05.00	585.5	353.5	1.650	-.1320	.0297	.0039	.0016
532	-03.05	-06.19	00.91	04.93	585.6	351.9	1.658	-.1342	.0249	.0011	.0002
533	-01.21	-06.81	04.0[illegible]	07.46	585.7	352.7	1.647	-.2041	.0281	.0003	.0007
534	-04.13	-06.39	00.6[illegible]	07.43	585.8	356.0	1.631	-.2014	.0313	.0023	.0016
535	-01.99	-05.83	03.2[illegible]	07.47	584.2	358.6	1.616	-.1999	.0290	.0004	.0009
536	-00.11	-07.34	05.15	07.46	586.2	353.5	1.644	-.2043	.0265	-.0000	.0001
537	01.96	-08.41	07.5[illegible]	07.44	587.0	349.3	1.666	-.2086	.0211	-.0000	-.0014

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
48	1	12	614	1	0627	1433	0.509	1.254	0949.	144.3	121.2	.0839	00.70	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
538	00.38	-04.94	01.16	00.00	586.4	285.7	2.053	.0078	.0153	.0010	.0008
539	-01.61	-06.68	-01.73	00.02	586.8	269.8	2.175	.0104	.0203	.0013	.0003
540	-02.85	-05.53	-03.37	00.03	585.7	270.6	2.164	.0127	.0256	.0024	.0015
541	01.27	-09.87	04.42	04.93	586.2	279.0	2.094	-.1678	.0240	.0008	.0003
542	01.70	-09.05	05.83	04.91	587.0	273.1	2.142	-.1748	.0174	.0012	-.0009
543	-02.53	-07.02	00.13	04.96	585.6	268.1	2.176	-.1703	.0340	.0024	.0028
544	00.17	-07.59	03.34	04.94	586.5	269.8	2.166	-.1717	.0287	.0014	.0011
545	00.77	-04.04	01.62	-02.07	587.3	267.2	2.196	.0794	-.0019	.0014	-.0008
546	01.84	-04.51	04.17	-02.11	586.5	270.6	2.166	.0725	-.0136	.0028	-.0022
547	-02.95	-05.56	-05.31	-01.99	586.8	267.2	2.194	.0882	.0222	.0017	.0015

CRM	CL	CD	CT	CH	CC	CLR	CDR	LOD	DL	CRB	CORR
-.0003	.0071	.0017	.0075	.0018	.0053	.0075	.0018	03.55	01.01	-.0003	502
-.0003	.0037	.0018	.0040	.0019	.0051	.0040	.0019	01.73	00.53	-.0003	503
-.0004	-.0019	.0027	-.0020	.0028	.0043	-.0020	.0028	-00.64	-00.27	-.0004	504
-.0005	.0131	.0016	.0139	.0017	.0029	.0139	.0017	07.17	01.85	-.0005	505
-.0004	.0139	.0022	.0140	.0022	.0034	.0140	.0022	05.74	01.97	-.0004	506
-.0005	.0160	.0037	.0161	.0037	-.0025	.0141	.0037	04.58	02.26	-.0005	507
-.0005	.0163	.0022	.0160	.0006	.0017	.0179	.0022	07.72	02.60	-.0005	508
-.0005	.0143	.0020	.0146	.0002	.0047	.0146	.0021	06.08	02.03	-.0005	509
-.0005	.0102	.0026	.0106	.0017	.0045	.0104	.0026	03.51	01.45	-.0005	510
-.0005	.0188	.0025	.0190	.0009	.0004	.0188	.0025	07.35	02.66	-.0005	511
-.0007	.0213	.0037	.0200	.0017	-.0052	.0197	.0035	06.42	03.01	-.0007	512
-.0004	.0236	.0065	.0240	.0044	-.0144	.0236	.0065	04.33	03.36	-.0004	513
-.0005	.0223	.0050	.0211	.0028	-.0077	.0208	.0046	05.12	03.19	-.0005	514
-.0005	.0249	.0049	.0241	.0015	-.0086	.0237	.0046	05.92	03.55	-.0005	515
-.0005	.0272	.0061	.0294	.0027	-.0134	.0288	.0065	05.15	03.89	-.0005	516
-.0005	.0247	.0039	.0269	.0007	-.0056	.0266	.0042	06.98	03.53	-.0005	517
-.0006	.0242	.0031	.0244	-.0001	-.0026	.0242	.0031	08.32	03.47	-.0006	518
-.0005	.0220	.0029	.0238	.0000	.0019	.0226	.0031	07.25	03.16	-.0005	519

CRM	CL	CD	CT	CH	CC	CLR	CDR	LOD	DL	CRB	CORR
-.0005	.0094	.0013	.0132	.0013	.0053	.0192	.0018	06.30	01.35	-.0005	520
-.0004	.0029	.0015	.0040	.0021	.0052	.0040	.0021	01.69	00.41	-.0004	521
-.0003	-.0058	.0028	-.0081	[illegible]	.0036	-.0081	.0038	-01.99	-00.83	-.0003	522
-.0005	.0148	.0014	.0205	.0019	.0038	.0205	.0019	09.48	02.12	-.0005	523
-.0004	.0200	.0023	.0276	.0032	-.0039	.0279	.0032	09.45	02.87	-.0004	524
-.0006	.0246	.0046	.0350	.0065	-.0211	.0350	.0065	06.61	03.51	-.0006	525
-.0006	.0220	.0031	.0300	.0042	-.0106	.0300	.0042	08.47	03.16	-.0006	526
-.0005	.0197	.0022	.0273	.0006	.0006	.0271	.0030	08.93	02.81	-.0005	527
-.0005	.0171	.0020	.0242	.0006	.0015	.0241	.0029	08.13	02.45	-.0005	528
-.0006	.0241	.0034	.0342	.0016	-.0081	.0339	.0047	07.98	03.46	-.0006	529
-.0005	.0267	.0049	.0331	.0031	-.0173	.0327	.0060	06.75	03.83	-.0005	530
-.0006	.0292	.0065	.0407	.0053	-.0328	.0401	.0089	05.83	04.20	-.0006	531
-.0005	.0247	.0023	.0344	.0015	-.0112	.0342	.0045	06.91	03.55	-.0005	532
-.0006	.0279	.0040	.0368	.0005	-.0127	.0364	.0055	08.13	04.01	-.0006	533
-.0006	.0307	.0064	.0423	.0021	-.0284	.0416	.0086	06.04	04.42	-.0006	534
-.0006	.0287	.0042	.0385	.0005	-.0165	.0381	.0055	08.41	04.11	-.0006	535
-.0005	.0263	.0034	.0365	-.0001	-.0068	.0362	.0047	08.46	03.79	-.0005	536
-.0005	.0209	.0027	.0296	-.0001	.0041	.0296	.0038	07.30	03.02	-.0005	537

CRM	CL	CD	CT	CH	CC	CLR	CDR	LOD	DL	CRB	CORR
-.0005	.0153	.0017	.0322	.0020	.0008	.0322	.0020	15.43	02.21	-.0005	538
-.0005	.0203	.0013	.0480	.0030	-.0065	.0480	.0030	17.96	02.93	-.0005	539
-.0004	.0256	.0024	.0600	.0057	-.0252	.0600	.0057	13.14	03.69	-.0004	540
-.0009	.0239	.0026	.0531	.0017	-.0072	.0527	.0063	08.89	03.45	-.0009	541
-.0006	.0172	.0026	.0401	.0027	.0042	.0397	.0061	06.31	02.49	-.0006	542
-.0004	.0337	.0053	.0812	.0056	-.0554	.0804	.0126	07.99	04.86	-.0004	543
-.0006	.0285	.0039	.0679	.0034	-.0170	.0674	.0092	07.98	04.12	-.0006	544
-.0004	-.0018	.0014	-.0046	.0033	.0102	-.0044	.0035	-01.12	-00.27	-.0004	545
-.0002	-.0135	.0034	-.0320	.0067	.0046	-.0318	.0079	-03.93	-01.96	-.0002	546
-.0006	.0222	.0009	.0534	.0041	-.0147	.0525	.0023	33.76	03.21	-.0006	547

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 49, 50

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DELB
49	1	12	614	1	0627	1505	0.508	1.254	0953.	144.5	122.7	.0841	00.71	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
548	-00.93	-06.64	-01.98	00.13	586.2	244.6	2.396	.0099	.0259	.0026	.0016
549	-01.12	-06.37	-02.82	00.16	586.4	231.2	2.536	.0121	.0300	.0034	.0020
550	-00.17	-06.96	-00.98	00.13	586.7	237.1	2.475	.0097	.0250	.0021	.0013

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DELB
50	1	12	614	1	0627	2022	0.182	1.229	2123.	048.0	074.3	.2279	01.91	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
555	00.01	-01.75	01.34	00.06	205.2	702.0	0.292	.0039	.0574	.0044	-.0037
556	02.00	-01.93	01.86	00.26	205.1	701.2	0.292	.0070	.1133	.0039	-.0005
557	04.08	-02.30	02.77	00.45	202.7	699.5	0.290	.0102	.1730	.0015	.0026
558	05.94	-02.60	03.70	00.68	204.5	702.0	0.291	.0141	.2409	.0005	.0026
559	07.01	-02.69	04.40	00.72	205.5	681.9	0.301	.0152	.2525	.0010	.0028
560	-02.17	-00.91	-00.24	-00.18	205.5	699.5	0.294	.0000	-.0125	.0044	.0017
561	00.23	-01.16	01.03	-02.40	205.3	701.2	0.293	.0149	.0360	.0040	.0003
562	02.02	-01.32	01.55	-02.21	204.4	702.0	0.291	.0180	.0932	.0043	.0030
563	04.01	-01.64	02.34	-02.00	203.4	702.0	0.290	.0212	.1543	.0038	.0048
564	06.05	-01.95	03.32	-01.77	204.1	701.2	0.291	.0248	.2181	.0029	.0059
565	00.00	-01.01	00.80	-03.92	205.7	702.9	0.292	.0205	.0068	.0026	-.0004
566	01.91	-01.49	01.47	-03.74	205.5	701.2	0.292	.0235	.0599	.0027	.0009
567	03.99	-01.73	02.31	-03.51	204.3	699.5	0.291	.0269	.1247	.0025	.0026
568	05.94	-02.00	03.18	-03.29	202.3	699.5	0.289	.0305	.1935	.0025	.0043
569	-02.17	-00.12	-01.24	-04.17	205.0	700.4	0.292	.0164	-.0661	.0016	.0062
570	-00.10	-02.04	01.47	05.40	204.0	702.9	0.289	-.0187	.1178	.0063	-.0003
571	01.88	-02.40	02.38	05.60	204.4	702.0	0.290	-.0156	.1759	.0047	.0002
572	04.06	-02.90	03.15	05.81	202.9	699.5	0.289	-.0118	.2406	.0016	.0011
573	06.03	-03.33	04.50	05.96	205.6	702.9	0.291	-.0097	.2809	-.0033	.0000
574	07.06	-03.81	05.34	06.02	204.5	698.7	0.291	-.0087	.2998	-.0010	-.0028
575	-02.03	-01.37	00.44	05.20	205.3	702.0	0.291	-.0224	.0567	.0055	.0019
576	-00.01	-02.21	01.80	07.91	204.7	700.4	0.289	-.0294	.1475	.0098	-.0015
577	02.00	-02.77	02.63	08.11	205.3	697.9	0.291	-.0264	.2042	.0071	-.0004
578	03.94	-03.20	03.65	08.28	206.8	699.5	0.293	-.0236	.2551	-.0025	.0006
579	06.01	-03.57	05.17	08.41	206.2	699.5	0.292	-.0214	.2925	-.0045	-.0014
580	01.90	-07.72	02.76	00.24	204.4	701.2	0.291	.0043	.0764	-.0007	-.0418
581	02.02	-04.11	02.84	00.30	205.3	704.6	0.291	.0052	.0920	.0002	-.0191
582	01.98	-00.02	02.81	00.35	205.1	702.9	0.292	.0061	.1084	.0039	.0072
583	02.40	03.63	03.08	00.30	205.0	702.0	0.292	.0052	.0919	-.0063	.0320
584	02.56	-02.37	05.96	00.25	205.9	702.0	0.293	.0044	.0771	-.0015	-.0229
585	01.32	-01.56	-00.18	00.33	205.5	703.7	0.292	.0060	.1047	.0057	.0110
586	01.99	-01.64	-00.11	00.42	204.3	703.7	0.290	.0073	.1297	.0062	.0124
587	01.90	-01.58	-02.66	00.49	205.7	702.9	0.293	.0083	.1476	.0092	.0254

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0006	.0259	.0027	.0743	.0075	-.0278	.0743	.0077	11.42	03.74	-.0006	548
-.0005	.0300	.0035	.0966	.0111	-.0592	.0966	.0113	10.71	04.35	-.0005	549
-.0006	.0250	.0021	.0765	.0063	-.0186	.0765	.0065	13.34	03.62	-.0006	550

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0574	.0045	.0025	.0002	.0021	.0025	.0002	02.68	02.75	-.0004	555
-.0011	.1133	.0044	.0048	.0002	.0022	.0048	.0002	05.23	05.43	-.0011	556
-.0016	.1730	.0028	.0073	.0001	.0026	.0073	.0001	07.11	08.09	-.0016	557
-.0019	.2409	.0033	.0102	.0000	.0035	.0102	.0001	07.56	11.47	-.0018	558
-.0021	.2524	.0041	.0115	.0000	.0043	.0115	.0002	07.15	12.12	-.0019	559
-.0004	-.0125	.0045	-.0005	.0002	.0025	-.0005	.0002	-00.51	-00.60	-.0005	560
-.0008	.0361	.0024	.0015	.0002	.0022	.0015	.0001	01.78	01.73	-.0006	561
-.0012	.0933	.0007	.0040	.0002	.0025	.0040	.0000	04.51	04.43	-.0012	562
-.0015	.1543	-.0016	.0065	.0002	.0029	.0065	-.0001	06.92	07.26	-.0014	563
-.0020	.2181	-.0038	.0092	.0001	.0039	.0092	-.0002	07.80	10.34	-.0019	564
-.0003	.0070	.0022	.0003	.0001	.0023	.0003	.0001	00.34	00.34	-.0003	565
-.0008	.0599	-.0012	.0026	.0001	.0026	.0026	-.0001	03.12	02.88	-.0008	566
-.0014	.1246	-.0051	.0053	.0001	.0031	.0053	-.0002	06.18	05.92	-.0013	567
-.0019	.1933	-.0086	.0081	.0001	.0041	.0081	-.0004	07.58	09.00	-.0018	568
-.0000	-.0658	.0064	-.0028	.0001	.0028	-.0028	.0003	-02.29	-03.15	-.0001	569
-.0015	.1167	.0173	.0050	.0003	.0011	.0049	.0007	04.47	05.52	-.0015	570
-.0016	.1746	.0218	.0075	.0002	.0009	.0074	.0009	05.98	08.30	-.0016	571
-.0022	.2392	.0259	.0101	.0001	.0011	.0101	.0011	06.79	11.21	-.0022	572
-.0021	.2798	.0259	.0120	-.0001	.0026	.0120	.0011	05.99	13.45	-.0020	573
-.0020	.2982	.0305	.0128	-.0000	.0034	.0128	.0013	05.17	14.20	-.0019	574
-.0010	.0559	.0107	.0024	.0002	.0014	.0024	.0005	02.52	02.68	-.0010	575
-.0017	.1448	.0300	.0063	.0004	.0003	.0062	.0013	04.51	06.90	-.0017	576
-.0015	.2012	.0359	.0088	.0003	.0000	.0087	.0016	05.55	09.65	-.0015	577
-.0014	.2528	.0343	.0111	-.0001	.0006	.0110	.0015	06.55	12.30	-.0014	578
-.0021	.2901	.0383	.0127	-.0002	.0024	.0126	.001[illegible]	05.12	14.03	-.0020	579
-.0192	.0764	-.0004	.0032	-.0000	.0031	.0032	-.0000	03.12	03.63	-.0192	580
-.0024	.0920	.0007	.0039	.0000	.0025	.0039	.0000	04.40	04.41	-.0024	581
.0103	.1084	.0046	.0046	.0002	.0022	.0046	.0002	04.86	05.19	.0103	582
.0244	.0920	-.0059	.0039	-.0003	.0030	.0039	-.0003	04.95	04.40	.0245	583
.0197	.0771	-.0012	.0033	-.0001	.0035	.0033	-.0001	02.92	03.72	.0197	584
-.0084	.1047	.0063	.0045	.0002	.0015	.0045	.0003	05.64	05.03	-.0083	585
-.0098	.1296	.0071	.0055	.0003	.0015	.0055	.0003	06.66	06.16	-.0098	586
-.0212	.1476	.0105	.0063	.0004	.0008	.0063	.0005	08.74	07.11	-.0212	587

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 51, 52

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
51	1	12	614	1	0627	2119	0.286	1.874	2121.	115.0	078.8	.2204	01.85	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
588	-00.32	-01.55	00.77	00.02	323.1	697.9	0.463	.0013	.0125	.0033	-.0007
589	01.84	-00.63	01.55	00.11	323.4	699.5	0.462	.0035	.0386	.0040	.0040
590	04.00	-02.29	03.75	00.15	323.3	698.7	0.463	.0045	.0496	.0027	-.0019
591	06.03	-02.74	05.23	00.21	324.0	699.5	0.463	.0062	.0680	.0020	-.0020
592	-02.01	-01.71	-00.62	-00.04	323.4	702.0	0.461	-.0005	-.0068	.0034	-.0019
593	-04.02	-01.29	-01.85	-00.10	323.1	700.4	0.461	-.0021	-.0250	.0028	-.0029
594	-00.08	-01.56	01.94	05.03	323.4	699.5	0.461	-.0352	.0457	.0046	.0016
595	02.04	-02.02	03.32	05.08	323.4	700.4	0.460	-.0337	.0622	.0037	.0012
596	03.98	-00.78	04.43	05.13	323.5	700.4	0.460	-.0325	.0756	.0001	.0071
597	05.94	-01.32	06.06	05.17	323.5	697.9	0.462	-.0316	.0872	-.0003	.0063
598	-02.05	-02.13	01.07	04.75	323.9	703.7	0.459	-.0369	.0242	.0039	-.0022
599	-04.06	-01.55	-00.77	04.90	324.0	700.4	0.461	-.0385	.0085	.0043	-.0009
600	-00.04	-01.86	02.66	07.58	323.4	702.9	0.456	-.0539	.0587	.0055	.0013
601	01.86	-02.05	03.92	07.63	324.1	701.2	0.458	-.0529	.0731	.0020	.0026
602	04.00	-01.89	05.37	07.68	324.7	702.9	0.458	-.0518	.0863	-.0004	.0040
603	06.00	-01.98	06.86	07.71	323.1	714.6	0.448	-.0497	.0967	-.0000	.0045
604	-02.02	-01.87	01.37	07.50	324.4	702.9	0.458	-.0557	.0400	.0064	-.0004
605	-03.97	-01.74	-00.02	07.45	324.1	701.2	0.458	-.0573	.0230	.0062	-.0006
606	-00.01	-01.91	03.20	10.08	323.6	707.9	0.450	-.0717	.0725	.0058	.0018
607	01.69	-01.81	04.54	10.10	323.6	701.2	0.454	-.0714	.0831	.0031	.0041
608	03.93	-02.32	06.06	10.17	323.8	703.7	0.453	-.0701	.0968	.0012	.0033
609	-02.07	-01.63	01.46	10.02	324.1	699.5	0.456	-.0744	.0532	.0093	.0027

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
52	1	12	614	1	0627	2203	0.286	1.052	2122.	115.1	083.9	.2184	01.83	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
610	-00.11	-01.98	01.02	-00.07	324.7	565.5	0.574	.0014	.0047	.0021	-.0003
611	01.86	-01.19	02.02	-00.03	324.4	563.8	0.575	.0028	.0171	.0024	.0033
612	03.99	-02.12	04.15	-00.01	324.4	560.5	0.579	.0036	.0246	.0022	.0015
613	05.98	-01.66	05.29	00.04	324.6	563.0	0.577	.0051	.0385	.0027	.0037
614	-01.98	-01.23	-00.96	-00.09	323.6	563.0	0.575	.0005	-.0023	.0022	.0019
615	-00.04	-01.97	02.55	05.04	323.6	565.5	0.570	-.0461	.0293	.0035	.0022
616	02.07	-02.16	04.05	05.06	324.2	562.1	0.574	-.0454	.0383	.0028	.0027
617	03.90	-02.13	05.25	05.10	323.7	562.1	0.574	-.0442	.0486	.0028	.0039
618	05.94	-03.17	07.06	05.13	324.2	563.8	0.573	-.0432	.0571	.0020	.0019
619	-02.06	-01.42	00.95	05.01	324.1	567.2	0.569	-.0470	.0204	.0035	.0027
620	-04.04	-01.02	-00.93	04.97	324.0	564.6	0.572	-.0479	.0126	.0036	.0038
621	-06.14	-00.67	-02.84	04.94	323.6	563.0	0.573	-.0489	.0043	.0036	.0038
622	-07.09	00.11	-06.33	04.99	323.8	562.1	0.574	-.0480	.0148	.0079	.0137
623	-01.09	00.69	00.12	05.05	324.7	559.6	0.578	-.0461	.0345	.0051	.0113
624	-01.01	01.27	-00.21	05.05	324.7	611.6	0.529	-.0420	.0359	.0021	.0138
625	-00.54	01.64	-00.03	05.06	324.4	645.9	0.500	-.0396	.0372	.0022	.0152
626	-00.41	01.35	-00.13	05.08	324.0	674.4	0.479	-.0375	.0426	.0037	.0157
627	-01.12	00.87	00.02	05.04	324.6	559.6	0.578	-.0460	.0346	.0050	.0111
628	00.05	-02.25	03.36	07.66	324.5	563.8	0.570	-.0708	.0410	.0030	.0030
629	02.04	-02.76	04.82	07.70	324.2	563.0	0.571	-.0700	.0494	.0028	.0026
630	03.95	-03.25	06.23	07.72	324.3	563.0	0.571	-.0691	.0580	.0023	.0019
631	06.00	-03.66	07.82	07.77	324.0	565.5	0.568	-.0677	.0678	.0014	.0018
632	01.96	-03.95	05.29	07.68	323.5	565.5	0.567	-.0702	.0435	.0025	-.0014
633	-02.13	-02.23	01.92	07.63	324.0	570.5	0.563	-.0712	.0295	.0045	.0018
634	-04.05	-01.81	00.26	07.60	324.2	565.5	0.568	-.0730	.0200	.0053	.0017
635	-05.93	-01.61	-01.21	07.58	324.1	563.0	0.571	-.0742	.0114	.0047	.0007
636	-00.65	-01.01	02.36	07.67	324.2	559.6	0.574	-.0715	.0398	.0048	.0060
637	-00.12	-04.76	05.03	09.90	324.9	565.5	0.566	-.0931	.0395	.0023	-.0042
638	03.87	-05.70	07.85	09.93	324.5	564.6	0.566	-.0910	.0562	.0005	-.0051
639	-03.85	-02.37	01.22	09.87	324.3	566.3	0.564	-.0938	.0309	.0061	.0013
640	-01.93	-02.75	02.80	09.90	324.6	567.2	0.564	-.0929	.0384	.0039	.0012

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0125	.0033	.0013	.0004	.0025	.0013	.0004	01.48	01.44	-.0006	588
-.0008	.0386	.0041	.0041	.0004	.0015	.0041	.0004	05.32	04.44	-.0008	589
-.0006	.0496	.0028	.0053	.0003	.0024	.0053	.0003	06.41	05.71	-.0006	590
-.0007	.0680	.0022	.0073	.0002	.0033	.0073	.0002	07.73	07.65	-.0007	591
-.0003	-.0068	.0034	-.0007	.0004	.0034	-.0007	.0004	-00.66	-00.78	-.0003	592
-.0001	-.0250	.0028	-.0027	.0003	.0046	-.0027	.0003	-02.04	-02.87	-.0001	593
-.0008	.0451	.0096	.0049	.0005	-.0000	.0048	.0009	05.29	05.18	-.0008	594
-.0009	.0617	.0092	.0066	.0004	-.0000	.0066	.0010	06.71	07.08	-.0009	595
-.0010	.0753	.0069	.0081	.0000	.0011	.0080	.0007	08.18	08.65	-.0010	596
-.0010	.0869	.0076	.0094	-.0000	.0025	.0093	.0008	06.93	09.98	-.0010	597
-.0006	.0238	.0059	.0026	.0004	.0014	.0025	.0006	02.69	02.73	-.0006	598
-.0006	.0081	.0050	.0009	.0005	.0024	.0009	.0005	00.83	00.93	-.0006	599
-.0006	.0575	.0132	.0062	.0006	-.0012	.0061	.0014	05.37	06.60	-.0008	600
-.0010	.0722	.0117	.0078	.0002	-.0005	.0077	.0012	06.79	08.32	-.0010	601
-.0010	.0856	.0111	.0092	-.0000	.0006	.0091	.0012	06.93	09.88	-.0010	602
-.0010	.0958	.0129	.0099	-.0000	.0024	.0098	.0013	05.26	10.97	-.0010	603
-.0007	.0388	.0116	.0043	.0007	-.0004	.0041	.0012	03.56	04.47	-.0007	604
-.0006	.0220	.0091	.0025	.0007	.0008	.0023	.0010	02.06	02.53	-.0006	605
-.0008	.0704	.0184	.0076	.0006	-.0022	.0074	.0019	05.07	08.07	-.0008	606
-.0011	.0813	.0176	.0089	.0003	-.0014	.0087	.0019	05.48	09.31	-.0011	607
-.0009	.0951	.0182	.0103	.0001	-.0003	.0101	.0019	05.37	10.90	-.0009	608
-.0009	.0508	.0104	.0057	.0010	-.0027	.0054	.0020	03.90	05.83	-.0009	609

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0047	.0021	.0006	.0004	.0022	.0008	.0004	01.06	00.54	-.0004	610
-.0007	.0171	.0024	.0026	.0004	.0011	.0028	.0004	04.78	01.97	-.0007	611
-.0005	.0246	.0022	.0041	.0004	.0018	.0041	.0004	05.96	02.82	-.0005	612
-.0007	.0385	.0027	.0064	.0004	.0023	.0064	.0004	07.52	04.43	-.0007	613
-.0004	-.0023	.0022	-.0004	.0004	.0024	-.0004	.0004	-00.49	-00.26	-.0004	614
-.0007	.0289	.0061	.0048	.0006	-.0008	.0047	.0010	05.56	03.31	-.0007	615
-.0006	.0379	.0062	.0064	.0005	-.0007	.0063	.0010	06.98	04.35	-.0006	616
-.0009	.0482	.0071	.0081	.0005	-.0003	.0080	.0012	07.07	05.51	-.0009	617
-.0008	.0567	.0071	.0094	.0003	.0015	.0094	.0012	06.58	06.50	-.0008	618
-.0006	.0200	.0053	.0033	.0006	-.0005	.0033	.0009	04.27	02.30	-.0006	619
-.0006	.0123	.0047	.0021	.0006	-.0000	.0020	.0008	02.65	01.41	-.0006	620
-.0005	.0040	.0039	.0007	.0006	.0014	.0007	.0006	00.73	00.45	-.0005	621
-.0071	.0141	.0091	.0025	.0013	-.0024	.0023	.0015	02.12	01.61	-.0071	622
-.0009	.0339	.0081	.0056	.0009	-.0037	.0057	.0014	07.85	03.90	-.0009	623
-.0009	.0355	.0052	.0051	.0005	-.0032	.0050	.0007	36.80	04.09	-.0009	624
-.0009	.0369	.0055	.0047	.0003	-.0028	.0047	.0007	36.82	04.23	-.0009	625
-.0009	.0421	.0074	.0049	.0004	-.0023	.0049	.0009	12.82	04.82	-.0009	626
-.0008	.0340	.0081	.0058	.0006	-.0037	.0057	.0014	08.01	03.91	-.0008	627
-.0007	.0402	.0085	.0066	.0005	-.0026	.0067	.0014	07.02	04.62	-.0007	628
-.0007	.0486	.0094	.0082	.0005	-.0020	.0081	.0016	06.69	05.57	-.0007	629
-.0009	.0571	.0100	.0096	.0004	-.0009	.0095	.0017	06.32	06.55	-.0009	630
-.0008	.0670	.0105	.0111	.0002	.0009	.0110	.0017	05.82	07.67	-.0008	631
-.0006	.0427	.0083	.0071	.0004	-.0010	.0070	.0014	05.93	04.68	-.0006	632
-.0008	.0286	.0084	.0048	.0007	-.0021	.0046	.0014	04.71	03.27	-.0008	633
-.0006	.0192	.0079	.0033	.0009	-.0013	.0031	.0013	02.94	02.20	-.0006	634
-.0006	.0106	.0062	.0019	.0006	.0004	.0018	.0010	01.62	01.22	-.0006	635
-.0007	.0388	.0100	.0067	.0008	-.0036	.0065	.0017	06.32	04.45	-.0007	636
-.0006	.0386	.0091	.0065	.0004	-.0016	.0064	.0015	05.22	04.44	-.0006	637
-.0006	.0553	.0102	.0093	.0001	-.0002	.0091	.0017	05.58	06.34	-.0006	638
-.0006	.0294	.0113	.0051	.0010	-.0030	.0048	.0018	03.64	03.37	-.0006	639
-.0006	.0371	.0104	.0063	.0006	-.0034	.0061	.0017	05.45	04.27	-.0006	640

HC144R1070

APPENDIX B. ROTOR TEST RESULTS (Continued)

RUNS 53, 54, 55

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DELB
53	1	12	614	1	0628	1525	0.358	2.200	2120.	174.1	096.9	.2084	01.75	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
647	-00.77	-04.16	00.35	00.00	408.7	284.8	1.435	.0032	.0089	.0010	-.0001
648	-02.07	-04.44	-01.52	00.01	408.7	275.6	1.483	.0043	.0128	.0016	-.0001
649	-03.94	-03.79	-03.91	00.02	408.4	278.1	1.468	.0054	.0166	.0026	.0013
650	00.85	-04.21	02.51	-00.01	409.1	277.3	1.475	.0019	.0044	.0012	-.0002
651	-05.29	-03.92	-05.64	00.04	409.3	267.2	1.531	.0064	.0195	.0037	.0014
652	-00.49	-06.64	02.97	04.96	408.9	267.2	1.525	-.1258	.0168	.0006	-.0001
659	-00.29	-05.89	02.87	05.08	402.7	273.1	1.469	-.1230	.0204	.0010	.0010
660	-02.47	-05.39	00.60	05.09	402.5	306.6	1.308	-.1088	.0282	.0017	.0015
661	-02.47	-05.23	00.43	05.10	402.5	266.4	1.505	-.1253	.0238	.0020	.0017
662	-04.61	-05.84	-01.91	05.10	403.1	273.1	1.470	-.1219	.0252	.0030	.0015
663	-06.09	-06.38	-03.85	05.10	403.0	278.1	1.443	-.1192	.0264	.0042	.0018
664	-06.18	-06.37	-03.68	05.10	403.0	258.9	1.551	-.1282	.0264	.0043	.0017
665	00.28	-07.79	04.95	07.40	404.2	262.2	1.529	-.1902	.0213	.0008	.0000
666	-02.41	-07.77	01.99	07.40	404.2	271.4	1.477	-.1825	.0251	.0017	.0006
667	-04.14	-08.29	00.19	07.42	404.5	277.3	1.447	-.1784	.0273	.0025	.0004
668	02.14	-07.97	06.90	07.39	405.4	262.2	1.533	-.1915	.0194	.0005	-.0001

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DELB
54	1	12	614	1	0628	2215	0.358	2.245	2120.	173.7	087.6	.2120	01.78	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
669	-01.30	-02.66	-00.22	-00.12	404.8	350.2	1.156	.0046	.0072	.0017	.0004
670	-04.20	-02.00	-03.84	-00.11	405.0	360.2	1.124	.0052	.0106	.0021	.0014
671	-06.25	-01.93	-06.04	-00.10	405.7	353.5	1.148	.0054	.0120	.0028	.0015
672	01.42	-02.04	02.38	-00.02	405.9	355.2	1.143	.0024	.0072	.0013	.0013
673	00.09	-03.81	03.43	04.93	405.6	355.2	1.138	-.0931	.0174	.0013	.0009
674	-02.39	-03.75	00.95	04.93	405.6	364.4	1.109	-.0907	.0178	.0018	.0008
675	-04.51	-03.24	-01.31	04.93	405.8	351.9	1.149	-.0934	.0198	.0025	.0016
676	00.10	-05.45	04.10	04.91	406.3	353.5	1.145	-.0950	.0120	.0013	-.0013
677	02.08	-04.85	05.70	04.92	407.3	356.0	1.140	-.0941	.0139	.0012	-.0002
678	-00.13	-05.81	04.92	07.34	407.1	358.6	1.126	-.1394	.0200	.0010	-.0006
679	-02.29	-05.36	02.72	07.36	406.8	351.0	1.149	-.1423	.0214	.0016	.0001
680	-02.33	-05.68	02.79	07.34	406.9	351.0	1.150	-.1421	.0206	.0018	-.0002
681	-04.22	-05.03	00.78	07.36	407.3	363.6	1.111	-.1373	.0224	.0029	.0004
682	02.04	-05.59	06.90	07.34	407.9	351.9	1.150	-.1420	.0211	.0012	.0001

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DELB
55	1	12	614	1	0628	2238	0.358	2.209	2120.	173.7	094.5	.2093	01.76	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
683	-01.84	-02.38	-00.82	-00.09	407.3	433.1	0.940	.0023	.0034	.0017	.0001
684	-04.10	-01.89	-03.10	-00.08	407.6	437.3	0.932	.0025	.0051	.0019	.0007
685	-05.64	-01.36	-04.53	-00.08	407.5	452.4	0.901	.0026	.0056	.0018	.0007
686	-00.04	-02.24	01.1[illegible]	-00.09	408.5	432.3	0.945	.0025	.0041	.0015	.0003
692	01.07	-04.01	05.41	05.00	418.4	431.4	0.966	-.0808	.0152	.0014	.0001
693	-00.05	-03.70	04.28	05.01	418.6	429.8	0.970	-.0812	.0157	.0013	.0002
694	-02.43	-03.21	01.94	05.00	418.8	442.3	0.943	-.0787	.0162	.0014	.0007
695	-04.17	-02.70	00.18	05.01	419.0	452.4	0.923	-.0771	.0166	.0020	.0011
696	-05.80	-02.16	-01.99	05.02	419.3	453.2	0.922	-.0765	.0190	.0031	.0021
697	-07.43	-01.84	-03.69	05.01	419.7	459.9	0.909	-.0755	.0187	.0042	.0022
698	00.14	-05.23	06.52	09.96	409.8	434.0	0.930	-.1567	.0280	.0005	-.0003
699	01.93	-05.52	08.10	09.98	409.4	429.8	0.938	-.1584	.0277	.0002	-.0006
700	-02.16	-04.56	04.39	09.97	409.3	442.3	0.912	-.1541	.0269	.0012	.0001
701	-04.14	-04.61	02.59	09.97	410.9	424.7	0.953	-.1610	.0268	.0024	-.0005
702	-01.06	00.82	01.59	05.00	410.5	426.1	0.955	-.0771	.0271	.0012	.0073

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0089	.0010	.0092	.0011	.0015	.0092	.0011	07.85	01.59	-.0004	647
-.0005	.0128	.0017	.0140	.0018	.0006	.0140	.0018	07.55	02.22	-.0005	648
-.0005	.0166	.0020	.0179	.0021	-.0057	.0179	.0021	10.32	02.88	-.0005	649
-.0004	.0044	.0012	.0048	.0013	.0022	.0048	.0013	03.25	00.76	-.0004	650
-.0004	.0195	.0028	.0228	.0044	-.0146	.0228	.0044	06.62	03.39	-.0004	651
-.0005	.0167	.0021	.0197	.0007	-.0030	.0196	.0024	08.76	02.90	-.0005	652
-.0005	.0203	.0028	.0222	.0011	-.0076	.0220	.0030	08.75	03.54	-.0005	659
-.0005	.0230	.0038	.0200	.0015	-.0122	.0198	.0032	08.53	04.00	-.0005	660
-.0005	.0236	.0041	.0272	.0023	-.0190	.0269	.0047	07.78	04.10	-.0005	661
-.0005	.0249	.0052	.0275	.0033	-.0243	.0271	.0057	06.71	04.33	-.0005	662
-.0006	.0259	.0065	.0277	.0044	-.0316	.0272	.0068	05.84	04.50	-.0006	663
-.0005	.0260	.0066	.0320	.0052	-.0358	.0315	.0080	05.48	04.51	-.0005	664
-.0005	.0211	.0036	.0254	.0010	-.0097	.0250	.0042	06.94	03.67	-.0005	665
-.0006	.0247	.0050	.0279	.0019	-.0184	.0274	.0055	06.49	04.30	-.0006	666
-.0006	.0267	.0060	.0290	.0027	-.0247	.0284	.0064	06.00	04.65	-.0006	667
-.0006	.0191	.0030	.0231	.0006	-.0035	.0229	.0036	06.78	03.34	-.0006	668

CBM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0005	.0072	.0017	.0048	.0011	.0015	.0048	.0011	03.83	01.26	-.0005	669
-.0005	.0106	.0021	.0067	.0013	.0003	.0067	.0013	04.94	01.83	-.0005	670
-.0005	.0120	.0028	.0079	.0018	-.0010	.0079	.0018	04.57	02.10	-.0005	671
-.0004	.0072	.0013	.0047	.0009	.0005	.0047	.0009	05.26	01.26	-.0004	672
-.0005	.0172	.0028	.0113	.0008	-.0028	.0112	.0018	07.13	02.99	-.0005	673
-.0005	.0176	.0033	.0110	.0011	-.0042	.0109	.0021	06.44	03.05	-.0005	674
-.0005	.0195	.0042	.0132	.0017	-.0085	.0130	.0028	06.26	03.39	-.0005	675
-.0004	.0118	.0023	.0079	.0008	.0010	.0078	.0015	04.90	02.06	-.0004	676
-.0005	.0138	.0024	.0091	.0008	-.0003	.0090	.0016	05.90	02.40	-.0005	677
-.0005	.0197	.0035	.0129	.0006	-.0031	.0127	.0023	06.34	03.44	-.0005	678
-.0005	.0210	.0043	.0144	.0011	-.0072	.0141	.0029	06.17	03.66	-.0005	679
-.0005	.0202	.0044	.0138	.0012	-.0063	.0136	.0030	05.62	03.51	-.0005	680
-.0005	.0219	.0057	.0141	.0018	-.0095	.0137	.0036	05.01	03.81	-.0005	681
-.0005	.0208	.0038	.0142	.0008	-.0032	.0140	.0026	06.04	03.63	-.0005	682

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0034	.0017	.0015	.0008	.0023	.0015	.0008	01.50	00.59	-.0004	683
-.0005	.0051	.0019	.0022	.0008	.0024	.0022	.0008	02.02	00.89	-.0005	684
-.0004	.0056	.0018	.0023	.0007	.0026	.0023	.0007	02.26	00.98	-.0004	685
-.0004	.0041	.0014	.0019	.0006	.0019	.0019	.0006	02.20	00.72	-.0004	686
-.0005	.0151	.0028	.0072	.0007	-.0008	.0071	.0013	05.83	02.76	-.0005	692
-.0005	.0156	.0027	.0075	.0006	-.0013	.0074	.0013	06.43	02.84	-.0005	693
-.0005	.0160	.0028	.0072	.0006	-.0023	.0072	.0012	07.16	02.92	-.0005	694
-.0005	.0163	.0034	.0071	.0009	-.0030	.0070	.0015	06.14	02.98	-.0005	695
-.0009	.0187	.0048	.0081	.0013	-.0052	.0080	.0020	05.40	03.41	-.0009	696
-.0005	.0182	.0058	.0078	.0017	-.0062	.0076	.0024	04.36	03.33	-.0005	697
-.0005	.0275	.0053	.0125	.0002	-.0047	.0123	.0024	06.53	04.78	-.0005	698
-.0006	.0273	.0050	.0126	.0001	-.0027	.0124	.0023	06.24	04.74	-.0006	699
-.0006	.0263	.0058	.0115	.0005	-.0064	.0113	.0025	06.23	04.58	-.0006	700
-.0005	.0260	.0070	.0125	.0011	-.0079	.0121	.0033	04.98	04.53	-.0005	701
-.0006	.0269	.0036	.0124	.0006	-.0073	.0123	.0016	14.03	04.68	-.0006	702

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 56, 57

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
56	1	12	614	1	0629	1540	0.359	2.181	2115.	174.2	100.3	.2065	01.73	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
703	-02.00	-02.02	-00.57	-00.05	410.7	499.3	0.823	.0008	.0004	.0024	.0018
704	00.03	-01.20	01.03	-00.02	410.5	498.5	0.824	.0019	.0080	.0017	.0021
705	01.94	-01.53	02.93	-00.02	410.5	493.4	0.832	.0021	.0089	.0021	.0017
706	01.41	03.60	00.32	00.02	410.7	496.8	0.827	.0036	.0186	-.0006	.0122
707	03.78	-01.43	04.57	-00.01	410.8	490.9	0.837	.0025	.0114	.0024	.0022
708	-04.20	-00.71	-03.29	-00.02	410.9	495.1	0.830	.0014	.0055	.0021	.0023
709	-00.25	-02.43	02.97	04.93	410.8	491.8	0.832	-.0681	.0181	.0023	.0015
710	01.89	-03.09	05.05	04.93	410.9	491.8	0.832	-.0678	.0191	.0022	.0008
711	04.06	-03.57	07.08	04.94	411.2	495.1	0.827	-.0672	.0205	.0020	.0005
712	05.89	-04.11	06.70	04.95	410.8	500.1	0.818	-.0663	.0218	.0024	.0001
713	-02.23	-02.57	01.46	04.92	411.0	493.4	0.830	-.0684	.0149	.0023	.0008
714	-04.05	-01.70	-00.80	04.93	410.6	494.3	0.828	-.0680	.0160	.0029	.0023
715	00.14	-04.31	05.81	09.99	411.3	494.3	0.819	-.1377	.0319	.0016	.0001
716	02.02	-04.61	07.34	10.00	411.4	501.0	0.809	-.1357	.0336	.0013	.0000
717	03.90	-04.61	08.82	10.01	411.0	490.9	0.824	-.1376	.0374	.0010	.0006
718	-02.10	-03.34	03.62	09.99	411.1	492.6	0.822	-.1382	.0312	.0025	.0015
719	-04.04	-03.78	02.22	09.97	411.3	492.6	0.822	-.1390	.0267	.0036	.0001

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
57	1	12	614	1	0629	1558	0.359	2.173	2115.	174.3	102.0	.2059	01.73	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
720	-00.06	-01.14	00.73	-00.02	411.4	566.3	0.726	.0016	.0076	.0026	.0016
721	01.78	-01.62	02.40	-00.01	412.7	565.5	0.730	.0021	.0108	.0025	.0010
722	03.92	-01.96	04.34	-00.00	413.5	567.2	0.729	.0027	.0146	.0027	.0006
723	05.86	-01.47	05.70	00.02	411.8	563.8	0.730	.0034	.0204	.0031	.0025
724	08.03	-02.46	07.86	00.02	411.7	568.0	0.725	.0039	.0231	.0031	.0009
725	-02.10	-00.46	-01.71	-00.02	411.1	565.5	0.727	.0014	.0066	.0027	.0030
726	00.18	-03.28	03.42	04.99	411.1	564.6	0.725	-.0602	.0175	.0025	-.0012
727	00.04	-02.05	02.73	05.00	411.2	569.7	0.719	-.0588	.0231	.0028	.0019
728	01.82	-01.93	04.14	05.03	412.5	566.3	0.726	-.0587	.0281	.0029	.0025
729	03.86	-03.57	06.36	05.02	411.8	570.5	0.719	-.0584	.0268	.0024	-.0003
730	05.98	-03.96	08.32	05.03	411.5	568.8	0.721	-.0581	.0293	.0022	-.0007
731	-02.11	-02.20	01.27	04.99	411.5	566.3	0.724	-.0602	.0162	.0017	.0011
732	00.06	-03.54	05.06	09.99	410.5	563.8	0.717	-.1195	.0369	.0023	.0007
733	01.88	-03.81	06.48	09.99	412.7	564.6	0.720	-.1193	.0408	.0014	.0005
734	04.02	-04.43	08.22	10.00	412.0	565.5	0.717	-.1186	.0437	.0006	.0004
735	-02.25	-03.34	03.29	09.95	412.4	560.5	0.725	-.1216	.0303	.0030	.0002
736	-04.10	-03.47	01.74	09.95	412.6	563.0	0.722	-.1218	.0266	.0047	-.0005

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0004	.0024	.0001	.0008	.0024	.0001	.0008	00.12	00.07	-.0004	703
-.0006	.0080	.0017	.0027	.0006	.0013	.0027	.0006	03.76	01.40	-.0006	704
-.0005	.0089	.0021	.0031	.0007	.0014	.0031	.0007	03.43	01.55	-.0005	705
-.0007	.0186	-.0006	.0064	-.0002	-.0022	.0064	-.0002	-13.27	03.24	-.0007	706
-.0005	.0114	.0024	.0040	.0008	.0014	.0040	.0008	03.95	01.99	-.0005	707
-.0005	.0055	.0021	.0019	.0007	.0020	.0019	.0007	01.99	00.96	-.0005	708
-.0007	.0178	.0038	.0063	.0008	-.0017	.0062	.0013	05.53	03.11	-.0007	709
-.0005	.0188	.0038	.0067	.0008	-.0006	.0066	.0013	05.15	03.27	-.0005	710
-.0005	.0202	.0038	.0071	.0007	.0001	.0070	.0013	05.33	03.53	-.0005	711
-.0005	.0215	.0042	.0073	.0008	.0014	.0072	.0014	04.54	03.74	-.0005	712
-.0005	.0147	.0035	.0052	.0008	-.0009	.0051	.0012	04.55	02.56	-.0005	713
-.0005	.0157	.0043	.0055	.0010	-.0021	.0054	.0015	04.41	02.73	-.0005	714
-.0006	.0311	.0071	.0110	.0006	-.0042	.0108	.0025	05.48	05.43	-.0006	715
-.0006	.0329	.0071	.0113	.0004	-.0029	.0111	.0024	05.43	05.73	-.0006	716
-.0006	.0367	.0075	.0131	.0003	-.0016	.0129	.0026	05.28	06.38	-.0006	717
-.0006	.0303	.0079	.0109	.0009	-.0067	.0106	.0027	05.45	05.28	-.0006	718
-.0005	.0256	.0081	.0093	.0012	-.0057	.0089	.0028	04.15	04.47	-.0005	719

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LOD	DL	CRB	CORR
-.0004	.0076	.0026	.0020	.0007	.0019	.0020	.0007	02.09	01.32	-.0004	720
-.0005	.0108	.0025	.0029	.0007	.0019	.0029	.0007	03.11	01.90	-.0005	721
-.0005	.0146	.0027	.0039	.0007	.0022	.0039	.0007	03.78	02.56	-.0005	722
-.0005	.0204	.0031	.0054	.0008	.0024	.0054	.0008	04.72	03.56	-.0005	723
-.0005	.0231	.0031	.0061	.0008	.0041	.0061	.0008	04.39	04.04	-.0005	724
-.0005	.0066	.0027	.0018	.0007	.0017	.0018	.0007	01.82	01.15	-.0005	725
-.0004	.0172	.0040	.0046	.0007	.0004	.0046	.0011	04.08	02.99	-.0004	726
-.0006	.0228	.0048	.0060	.0007	-.0013	.0059	.0013	05.50	03.96	-.0006	727
-.0006	.0278	.0054	.0075	.0008	-.0013	.0074	.0014	05.94	04.86	-.0006	728
-.0006	.0265	.0047	.0070	.0006	.0005	.0069	.0012	05.33	04.62	-.0006	729
-.0005	.0290	.0048	.0077	.0006	.0022	.0076	.0012	04.88	05.04	-.0005	730
-.0005	.0160	.0031	.0043	.0005	-.0002	.0042	.0008	05.31	02.79	-.0005	731
-.0006	.0360	.0086	.0098	.0006	-.0037	.0095	.0023	05.34	06.23	-.0006	732
-.0006	.0399	.0085	.0109	.0004	-.0025	.0107	.0023	05.55	06.99	-.0006	733
-.0007	.0429	.0082	.0116	.0002	-.0007	.0114	.0022	05.48	07.48	-.0007	734
-.0007	.0293	.0082	.0082	.0008	-.0042	.0079	.0022	04.85	05.11	-.0007	735
-.0005	.0254	.0092	.0071	.0013	-.0035	.0068	.0025	03.42	04.43	-.0005	736

APPENDIX B. ROTOR TEST RESULTS (Continued)
RUNS 59, 60

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
59	1	12	614	1	0630	1446	0.434	2.933	2104.	243.5	104.5	.1982	01.66	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
752	-00.10	-02.45	00.74	-00.03	495.7	493.4	1.005	.0019	.0051	.0049	-.0007
753	01.91	-02.95	02.93	-00.04	496.5	493.4	1.006	.0015	.0037	.0044	-.0014
754	03.88	-03.29	04.86	-00.04	496.3	495.1	1.002	.0014	.0030	.0043	-.0017
755	-02.03	-01.84	-01.29	-00.02	496.7	494.3	1.005	.0020	.0063	.0054	-.0001
756	-04.05	-01.42	-03.73	-00.02	496.5	494.3	1.005	.0025	.0086	.0066	.0007
757	-06.15	-00.95	-05.89	-00.01	496.5	494.3	1.005	.0029	.0106	.0078	.0008
758	00.19	-04.18	03.61	05.00	497.5	490.9	1.010	-.0847	.0138	.0054	-.0020
759	01.82	-04.78	05.23	05.00	498.5	49[illegible]	[illegible].013	-.0855	.0123	.0047	-.0025
760	03.82	-05.34	07.34	04.99	498.0	49[illegible]	[illegible].009	-.0856	.0096	.0042	-.0032
761	-02.16	-03.36	01.18	05.01	497.9	490.1	1.012	-.0845	.0164	.0066	-.0011
762	-04.13	-02.84	-00.94	05.00	497.2	493.4	1.004	-.0834	.0178	.0085	-.0005
763	-06.23	-02.29	-03.42	05.02	497.3	493.4	1.004	-.0833	.0191	.0112	.0004
764	00.13	-04.65	04.72	07.40	498.6	490.9	1.007	-.1259	.0195	.0063	-.0021
765	01.88	-05.15	06.31	07.40	499.1	490.9	1.008	-.1261	.0188	.0057	-.0025
766	04.16	-05.77	08.32	07.39	499.1	493.4	1.003	-.1255	.0180	.0052	-.0029
767	-01.91	-04.20	02.66	07.41	499.1	493.4	1.003	-.1253	.0201	.0074	-.0017
768	-04.02	-03.95	00.5[illegible]	07.40	499.5	493.4	1.004	-.1250	.0210	.0095	-.0012
769	-05.94	-03.51	-01.40	07.41	499.3	493.4	1.003	-.1251	.0213	.0119	-.0010
770	00.16	-05.10	05.68	10.03	500.1	491.8	1.001	-.1699	.0285	.0074	-.0014
771	02.03	-05.51	07.25	10.04	500.5	491.8	1.002	-.1702	.0286	.0065	-.0017
772	03.31	-05.71	08.46	10.04	500.2	492.6	1.000	-.1700	.0280	.0059	-.0016
773	-01.93	-04.48	03.74	10.03	499.8	494.3	0.996	-.1691	.0272	.0093	-.0012
774	-04.07	-04.00	01.50	10.03	499.5	494.3	0.995	-.1696	.0251	.0107	-.0004
775	-00.13	-06.00	06.43	11.92	500.1	493.4	0.992	-.2014	.0312	.0080	-.0024
776	01.86	-06.49	08.22	11.92	500.9	492.6	0.995	-.2021	.0314	.0062	-.0026
777	02.96	-06.37	08.80	11.92	500.3	492.6	0.994	-.2018	.0319	.0053	-.0014
778	-02.04	-05.28	04.54	11.92	499.1	493.4	0.990	-.2012	.0305	.0093	-.0017
779	00.08	-05.59	06.68	14.04	497.7	493.4	0.979	-.2367	.0314	.0038	.0000

RUN	L	TN	TST	P	DATE	TIME	M	R	PT	Q	TT	RHO	GAMA	PHI	DEL3
60	1	12	614	1	0703	1025	0.433	2.634	2117.	244.4	089.6	.2048	01.72	000.0	26.00

CORR	THEZ	THEC	THES	ALFA	V	VTIP	MU	LAMB	CZ	CX	CPM
794	-00.13	-03.15	00.23	-00.07	488.5	350.2	1.395	.0054	.0104		
795	02.12	-04.05	03.27	-00.13	489.7	346.8	1.412	.0040	.0022		
796	03.82	-04.53	05.53	-00.14	490.2	346.8	1.413	.0018	-.0045		
797	-02.67	-03.70	-02.59	-00.08	490.3	345.2	1.421	.0064	.0124		
798	-03.97	-03.43	-04.30	-00.07	491.3	346.8	1.416	.0072	.0158		
799	-06.44	-03.93	-07.54	-00.07	491.1	346.0	1.420	.0073	.0157		
800	-00.60	-03.29	-00.20	-00.09	491.0	346.8	1.416	.0059	.0106		
801	00.10	-05.49	02.79	05.01	493.2	347.7	1.413	-.1175	.0182		
802	01.96	-05.52	04.75	05.00	492.5	348.5	1.408	-.1174	.0163		
803	03.82	-06.23	07.14	04.98	495.7	347.7	1.420	-.1199	.0109		
804	-02.20	-06.28	00.74	05.01	493.9	352.7	1.395	-.1162	.0170		
805	-04.29	-06.13	-01.73	05.02	493.8	347.7	1.415	-.1177	.0184		
806	-06.22	-06.45	-03.78	05.01	493.7	346.8	1.418	-.1174	.0195		
807	00.06	-07.00	04.25	07.49	494.6	349.3	1.404	-.1775	.0197		
808	01.86	-06.75	05.84	07.48	496.0	348.5	1.411	-.1783	.0194		
809	03.76	-07.19	07.87	07.47	495.5	346.8	1.417	-.1803	.0155		
810	-01.95	-07.07	02.14	07.48	495.7	346.0	1.420	-.1790	.0212		
811	-04.10	-07.30	-00.01	07.48	494.9	344.3	1.425	-.1795	.0214		
812	-06.52	-06.62	-02.71	07.50	493.5	347.7	1.407	-.1774	.0221		
813	00.24	-08.16	05.70	09.94	496.2	347.7	1.406	-.2380	.0236		
814	02.01	-08.52	07.33	09.94	496.5	345.2	1.417	-.2395	.0244		
815	03.98	-08.21	09.2[illegible]	09.94	496.7	345.2	1.418	-.2399	.0238		
816	-01.35	-07.80	04.[illegible]	09.95	496.0	348.[illegible]	1.4[illegible]2	-.2372	.0244		
817	-04.05	-07.19	01.[illegible]	[illegible]9.93	495.5	34[illegible]	[illegible]	-.236[illegible]	.0248		
818	-05.97	-07.30	-00.[illegible]	[illegible]9.94	496.1	346.[illegible]	1.4[illegible]	[illegible]	.[illegible]247		
819	00.02	-08.39	07.2[illegible]	12.44	496.7	349.[illegible]	1.3[illegible]	[illegible]	.[illegible]96		
820	01.84	-[illegible].06	08.84	12.43	497.7	345.[illegible]	1.4[illegible]8	[illegible]	.[illegible]84		
821	-01.89	-08.04	05.50	12.42	497.1	346[illegible]	1.4[illegible]3	-.2968	.0[illegible]		
822	-04.07	-07.72	03.46	12.43	496.5	34[illegible]	1.4[illegible]3	-.2947	.[illegible]		

HC144R1070

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LCD	DL	CRB	CORR
-.0003	.0051	.0049	.0026	.0025	.0032	.0026	.0025	00.91	01.23	-.0003	752
-.0003	.0037	.0044	.0019	.0022	.0034	.0019	.0022	00.72	00.90	-.0003	753
-.0003	.0030	.0043	.0015	.0022	.0038	.0015	.0022	00.60	00.74	-.0003	754
-.0003	.0063	.0054	.0032	.0027	.0031	.0032	.0027	01.05	01.54	-.0003	755
-.0004	.0086	.0066	.0044	.0033	.0023	.0044	.0033	01.23	02.10	-.0004	756
-.0004	.0106	.0078	.0053	.0040	.0016	.0053	.0040	01.30	02.57	-.0004	757
-.0004	.0133	.0065	.0071	.0027	.0016	.0068	.0034	01.94	03.23	-.0004	758
-.0004	.0119	.0058	.0064	.0025	.0025	.0061	.0030	01.89	02.89	-.0004	759
-.0002	.0092	.0050	.0049	.0022	.0034	.0047	.0026	01.62	02.25	-.0002	760
-.0004	.0158	.0081	.0085	.0034	-.0004	.0081	.0042	01.98	03.83	-.0004	761
-.0004	.0170	.0100	.0090	.0043	-.0026	.0086	.0051	01.80	04.11	-.0004	762
-.0005	.0180	.0129	.0097	.0057	-.0067	.0092	.0065	01.56	04.37	-.0005	763
-.0004	.0185	.0088	.0100	.0033	-.0006	.0095	.0045	02.13	04.49	-.0004	764
-.0004	.0179	.0080	.0097	.0029	.0009	.0093	.0042	02.18	04.36	-.0004	765
-.0004	.0172	.0075	.0092	.0027	.0026	.0088	.0038	02.15	04.18	-.0004	766
-.0004	.0190	.0100	.0103	.0038	-.0024	.0097	.0051	02.00	04.60	-.0004	767
-.0006	.0196	.0121	.0108	.0049	-.0059	.0101	.0062	01.78	04.77	-.0006	768
-.0004	.0196	.0146	.0109	.0061	-.0077	.0100	.0075	01.50	04.76	-.0004	769
-.0004	.0268	.0123	.0148	.0039	-.0060	.0139	.0064	02.40	06.52	-.0004	770
-.0004	.0270	.0114	.0148	.0034	-.0037	.0140	.0059	02.53	06.58	-.0004	771
-.0005	.0265	.0106	.0144	.0030	-.0026	.0137	.0055	02.62	06.45	-.0005	772
-.0003	.0252	.0139	.0139	.0047	-.0086	.0129	.0071	02.06	06.12	-.0003	773
-.0003	.0228	.0149	.0128	.0055	-.0113	.0117	.0076	01.79	05.53	-.0003	774
-.0004	.0289	.0143	.0160	.0041	-.0073	.0148	.0073	02.25	07.01	-.0004	775
-.0004	.0294	.0126	.0162	.0032	-.0040	.0152	.0065	02.49	07.15	-.0004	776
-.0004	.0301	.0118	.0164	.0027	-.0052	.0155	.0061	02.79	07.29	-.0004	777
-.0003	.0279	.0154	.0156	.0047	-.0103	.0143	.0079	02.09	06.73	-.0003	778
-.0003	.0295	.0112	.0159	.0019	-.0128	.0150	.0057	03.38	07.08	-.0003	779

CRM	CL	CD	CT	CH	CQ	CLR	CDR	LCD	DL	CRB	CORR
-.0004			.0101		.0004					-.0004	794
-.0003			.0022		.0034					-.0003	795
-.0003			-.0045		.0034					-.0003	796
-.0004			.0125		-.0039					-.0004	797
-.0004			.0158		-.0062					-.0004	798
-.0003			.0159		-.0168					-.0003	799
-.0004			.0108		.0007					-.0004	800
-.0004			.0183		-.0064					-.0004	801
-.0005			.0163		-.0033					-.0005	802
-.0004			.0111		.0009					-.0004	803
-.0004			.0172		-.0076					-.0004	804
-.0004			.0185		-.0163					-.0004	805
-.0003			.0197		-.0233					-.0003	806
-.0005			.0197		-.0082					-.0005	807
-.0004			.0196		-.0071					-.0004	808
-.0004			.0158		-.0020					-.0004	809
-.0004			.0217		-.0148					-.0004	810
-.0004			.0221		-.0207					-.0004	811
-.0005			.0223		-.0314					-.0005	812
-.0004			.0241		-.0136					-.0004	813
-.0004			.0252		-.0084					-.0004	814
-.0005			.0247		-.0044					-.0005	815
-.0004			.0247		-.0175					-.0004	816
-.0004			.0251		-.0296					-.0004	817
-.0004			.0253		-.0323					-.0004	818
-.0004			.0299		-.0143					-.0004	819
-.0004			.0295		-.0106					-.0004	820
-.0005			.0292		-.0231					-.0005	821
-.0004			.0284		-.0313					-.0004	922

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APPENDIX C AIRFOIL TESTS

C1 Models

To provide a basis for the prediction of rotor performance, three 18-inch chord airfoil models were constructed to the ordinates of the root (18% thick), mid-span (12% thick) and tip (6% thick) rotor blade airfoil sections. The 12% and 18% models were constructed in aluminum and the 6% model in steel. The models were fitted with orifices for pressure measurements at the stations shown in Table C-1.

C2 Wind Tunnel and Test Procedure

Pressure plotting tests were conducted in the 3 ft by 7-1/2 ft Low Turbulence Pressure Tunnel at NASA Langley Research Center during August 1972. Each model was tested with flow in both the forward and the reverse direction over the range of angles of attack from -10° to +24°, with the model rotating about 50% chord. Pressures were measured at the orifices detailed in Table C-1 and on a 96 port rake 33 inches downstream of the trailing edge of the model.

C3 Test Conditions

The tests were intended to cover both the low Reynolds numbers appropriate to the model rotor tests and the high Reynolds numbers experienced on the blades of a full scale helicopter. The conditions tested are shown in Table C-2. Most tests were made with the models smooth, but some tests at the lower Reynolds numbers were made with grit added to the surface in the leading edge area to induce transition. Number 80 grit was used in a band one-tenth inch wide at 5% chord (.9 in. aft of the leading edge).

C4 Results

Lift coefficient, drag coefficient and moment coefficient were obtained from the measured pressures by NASA Langley using the conventional computational methods, and are plotted in figures C1 through C28. Table C-2 provides a key to these figures.

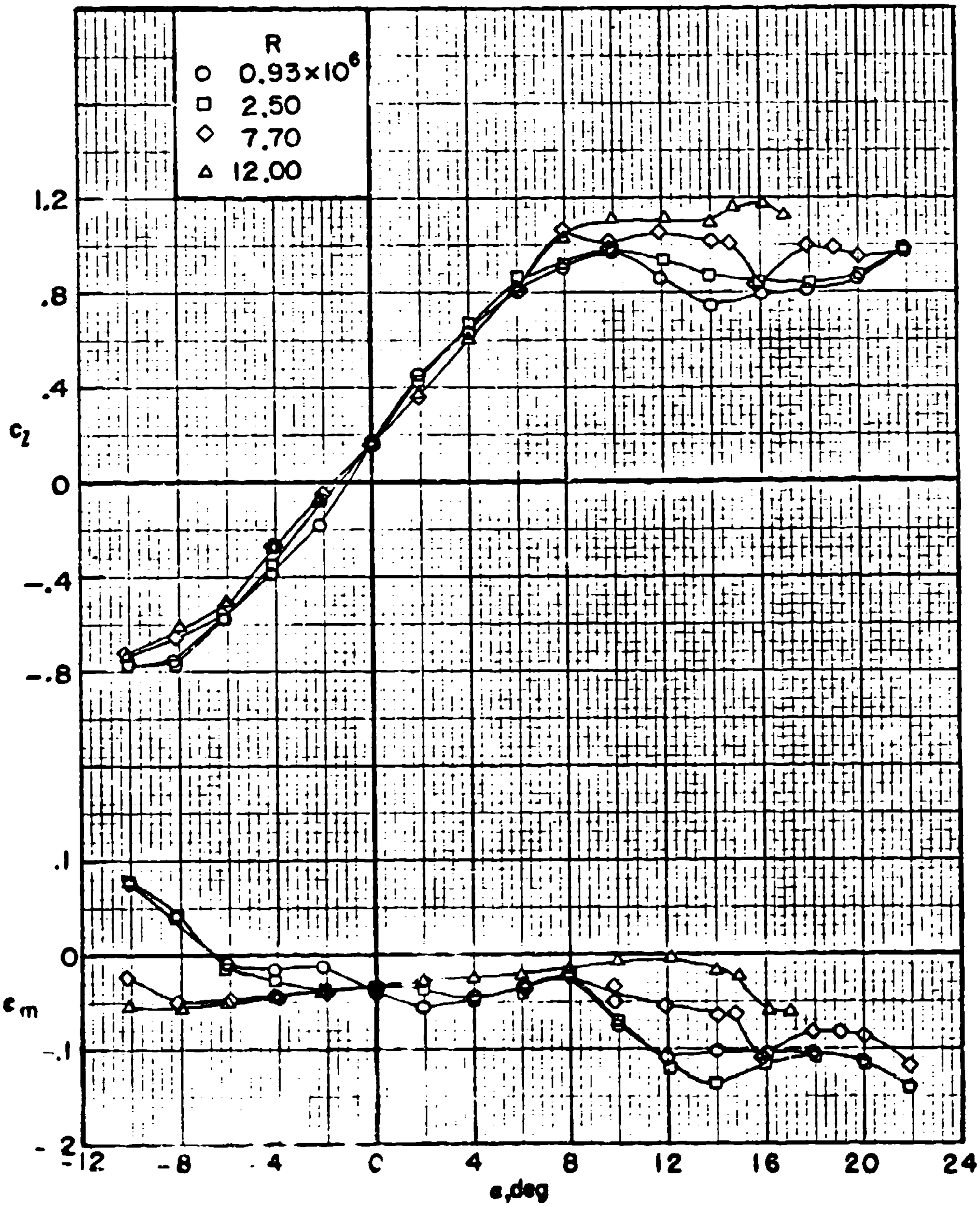
TABLE C-I. LOCATION OF ORIFICES IN 18-INCH CHORD AIRFOIL SECTIONS (UPPER AND LOWER SURFACES)

Percentage Chord	Inches from Leading Edge
0	0
.3	.054
.6	.108
1.2	.162
1.6	.282
2.0	.360
2.5	.450
3.75	.675
5.0	.900
7.5	1.350
10.0	1.800
15.0	2.700
20.0	3.600
25.0	4.500
30.0	5.400
40.0	7.200
50.0	9.000
60.0	10.800
70.0	12.600
75.0	13.500
80.0	14.400
85.0	15.300
90.0	16.200
92.5	16.650
95.0	17.100
96.25	17.325
97.5	17.550
98.0	17.640
98.5	17.730
99.0	17.820
99.5	17.910
100.0	18.000
1/3 Span	5.400
	12.600
2/3 Span	5.400
	12.600

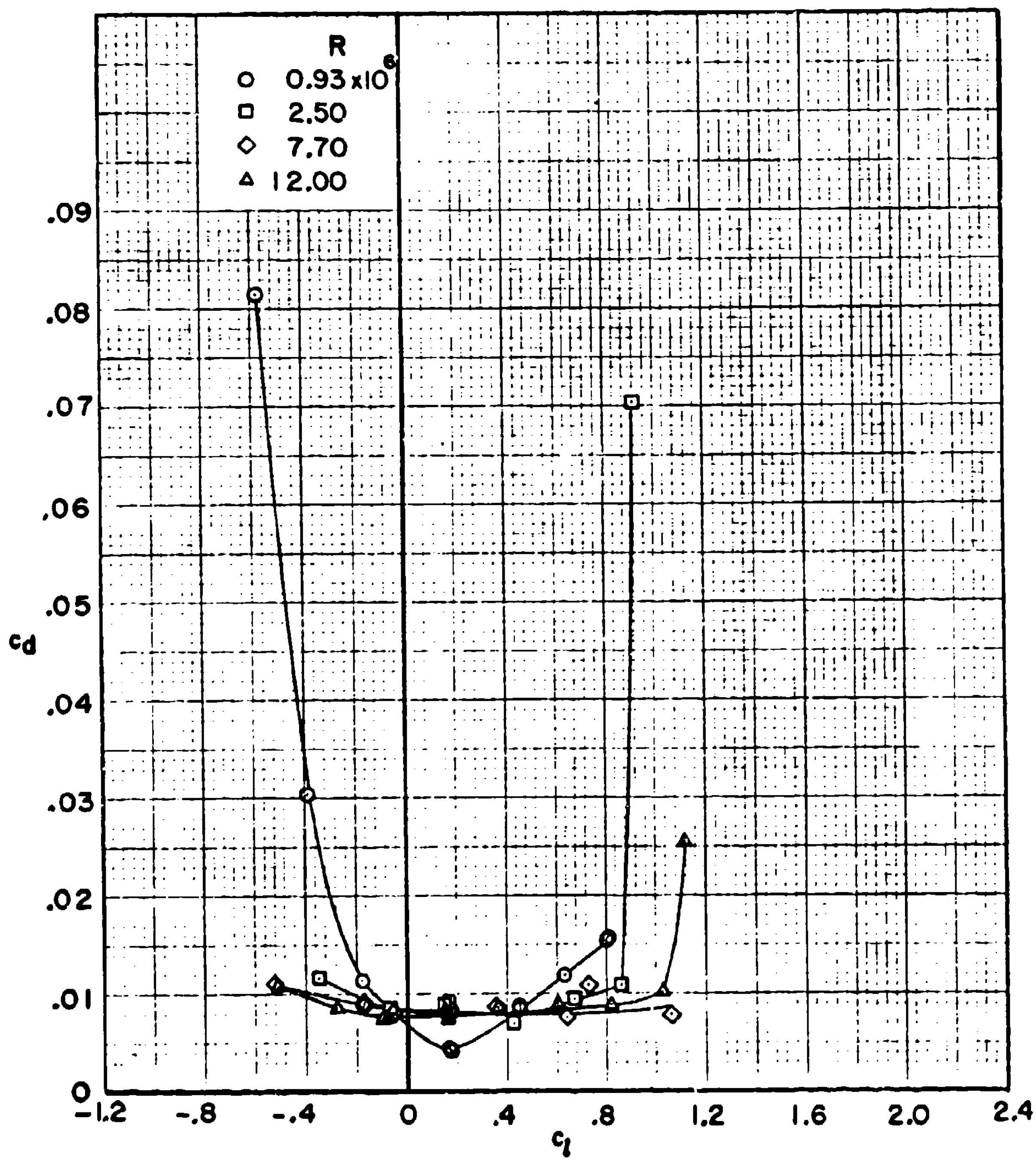
TABLE C-2. SCHEDULE OF AIRFOIL SECTION PRESSURE PLOTTING TESTS MADE IN LANGLEY LTPT

Reynolds Number (million)	M	Grit	Figure Number 6% Forward	6% Reverse	12% Forward	12% Reverse	18% Forward	18% Reverse
.93-.95	.26	off	1	5	10	15	20	24
2.5-2.6	.26	off	1	5	10	15	20	24
7.6-7.7	.26	off	1	5	10	15	20	24
11.65-12.0	.26	off	1	-	10	-	20	-
.93-.96	.26	on	2	6	11	16	21	25
2.5-2.6	.26	on	3	7	12	17	22	26
7.6-7.7	.26	on	-	8	-	18	-	27
11.65	.26	on	-	-	13	-	-	-
2.26-2.6	.16	off	4	9	14	19	23	28
2.26=2.6	.35	off	4	9	14	19	23	28

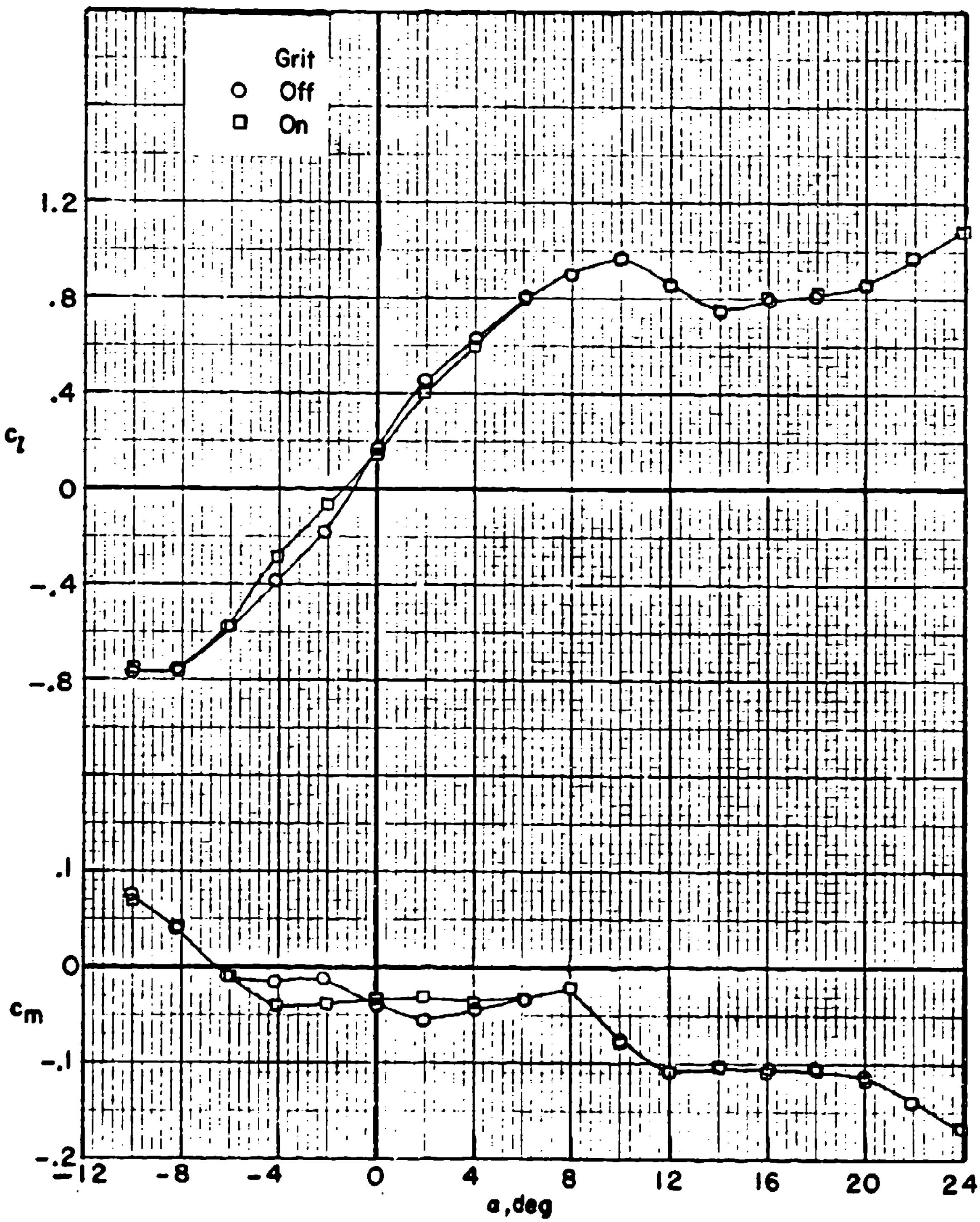
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; MODEL SMOOTH



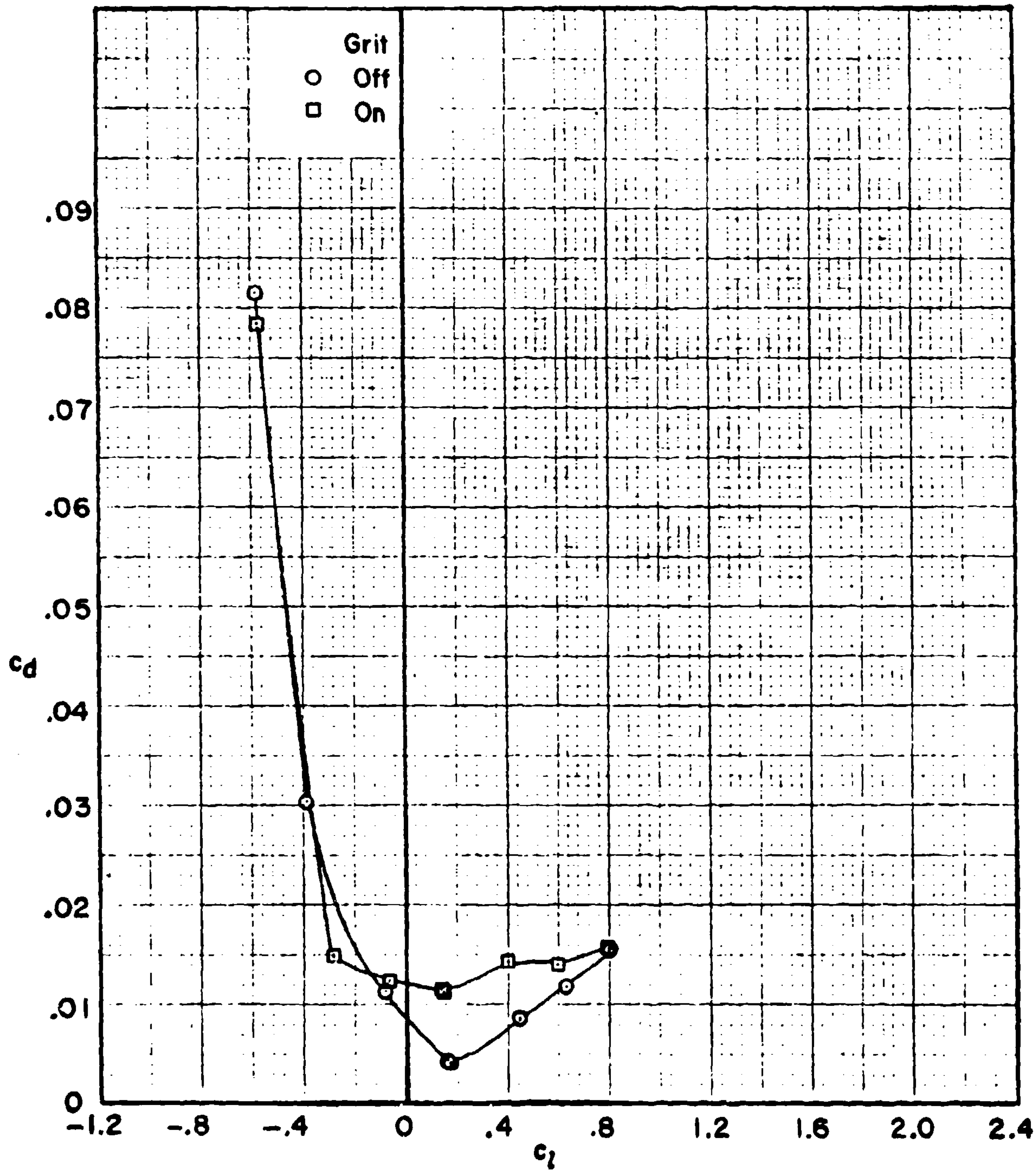
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; MODEL SMOOTH



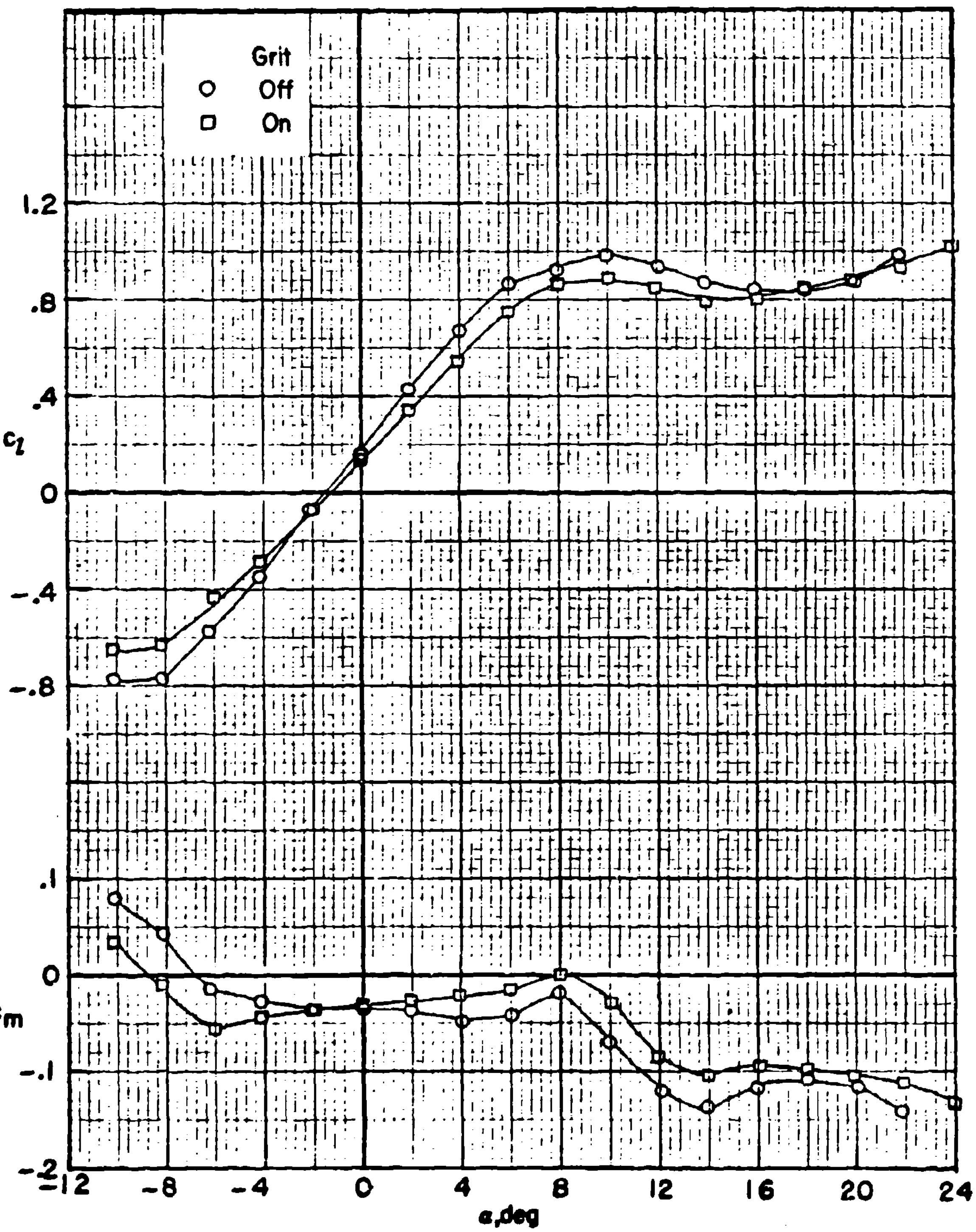
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. $M = 0.26; R = 0.93 \times 10^6$



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. $M = 0.26; R = 0.93 \times 10^6$



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M=0.26; R=2.60 x10^{6}



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. $M = 0.26; R = 2.60 \times 10^6$

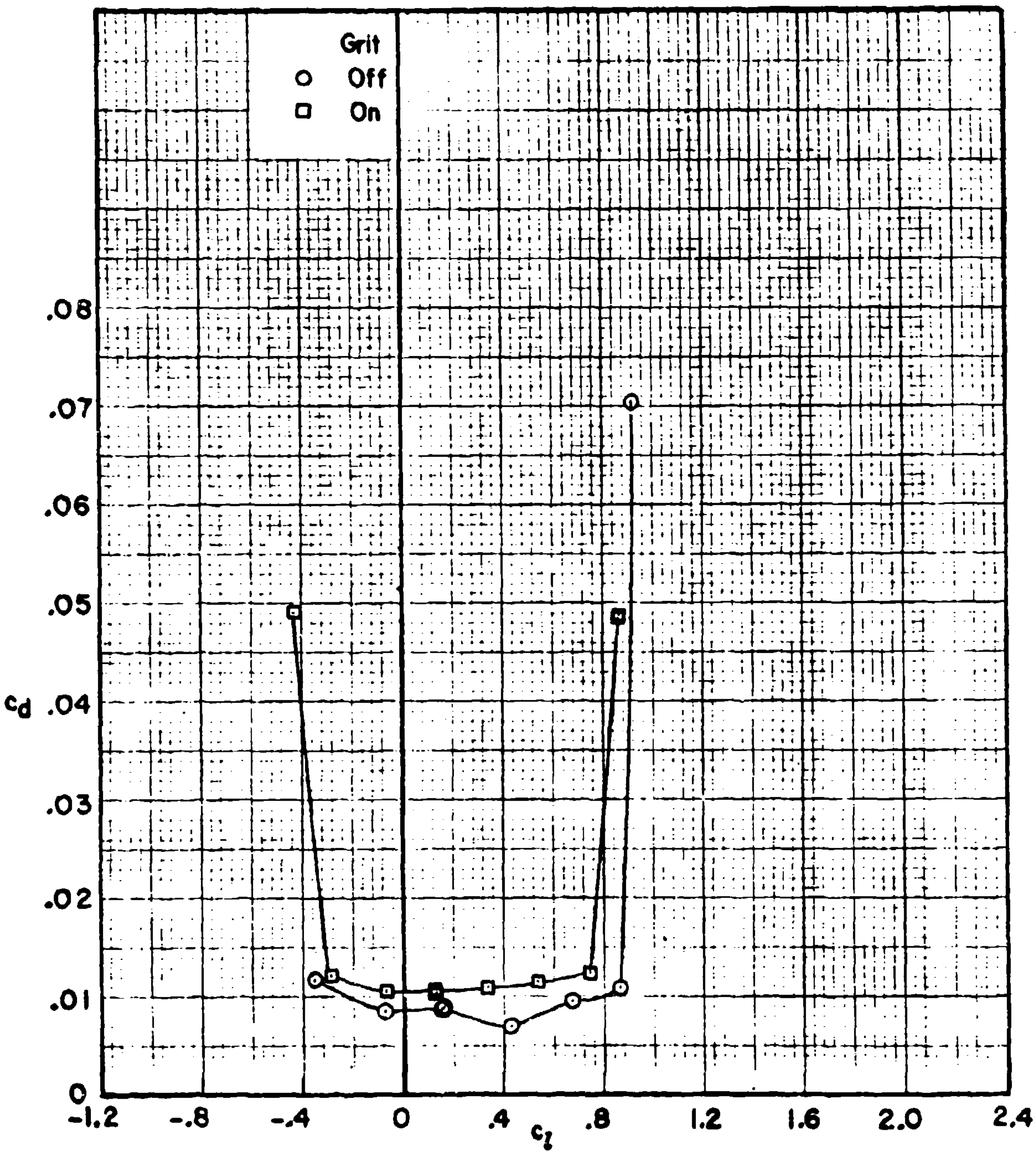
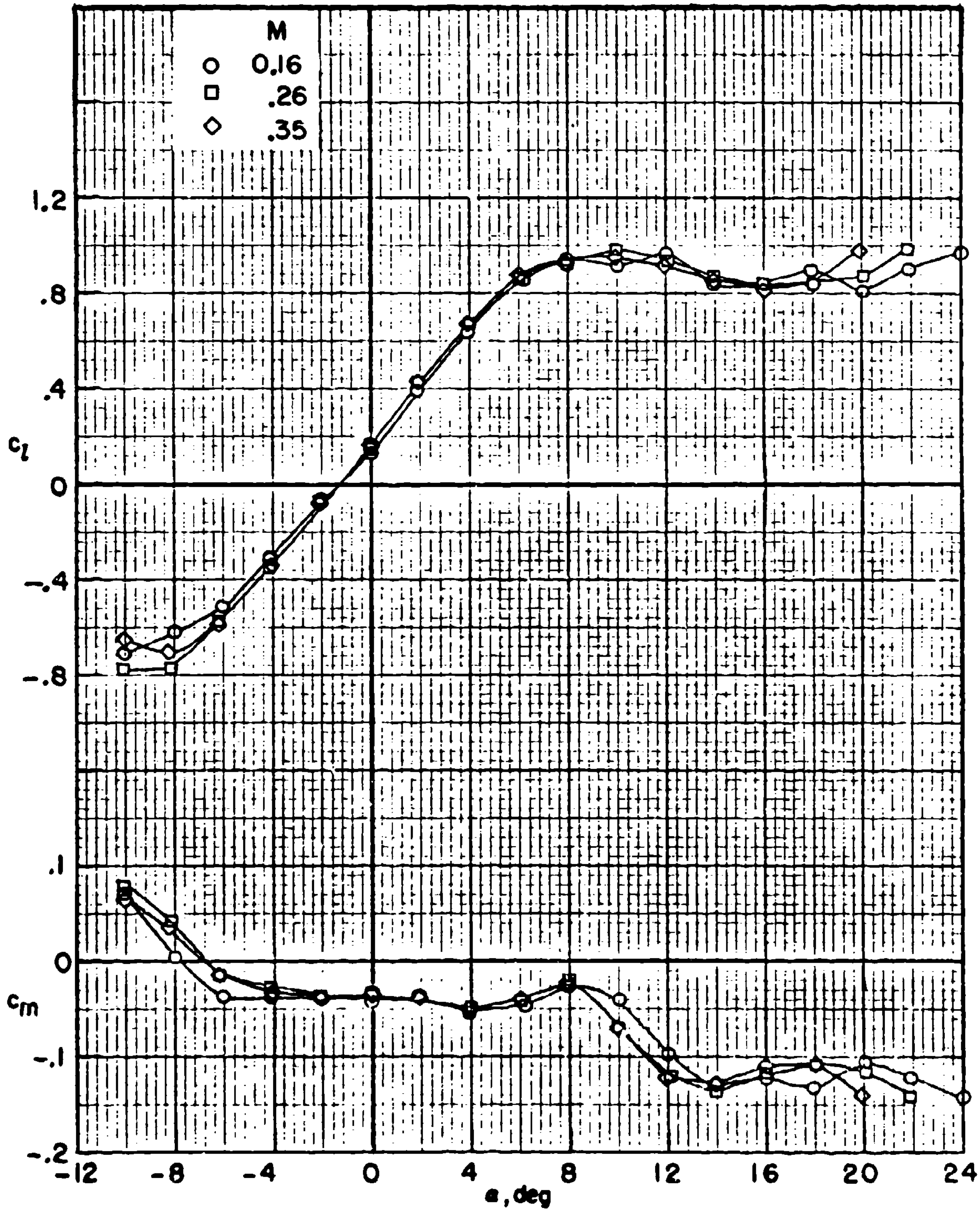
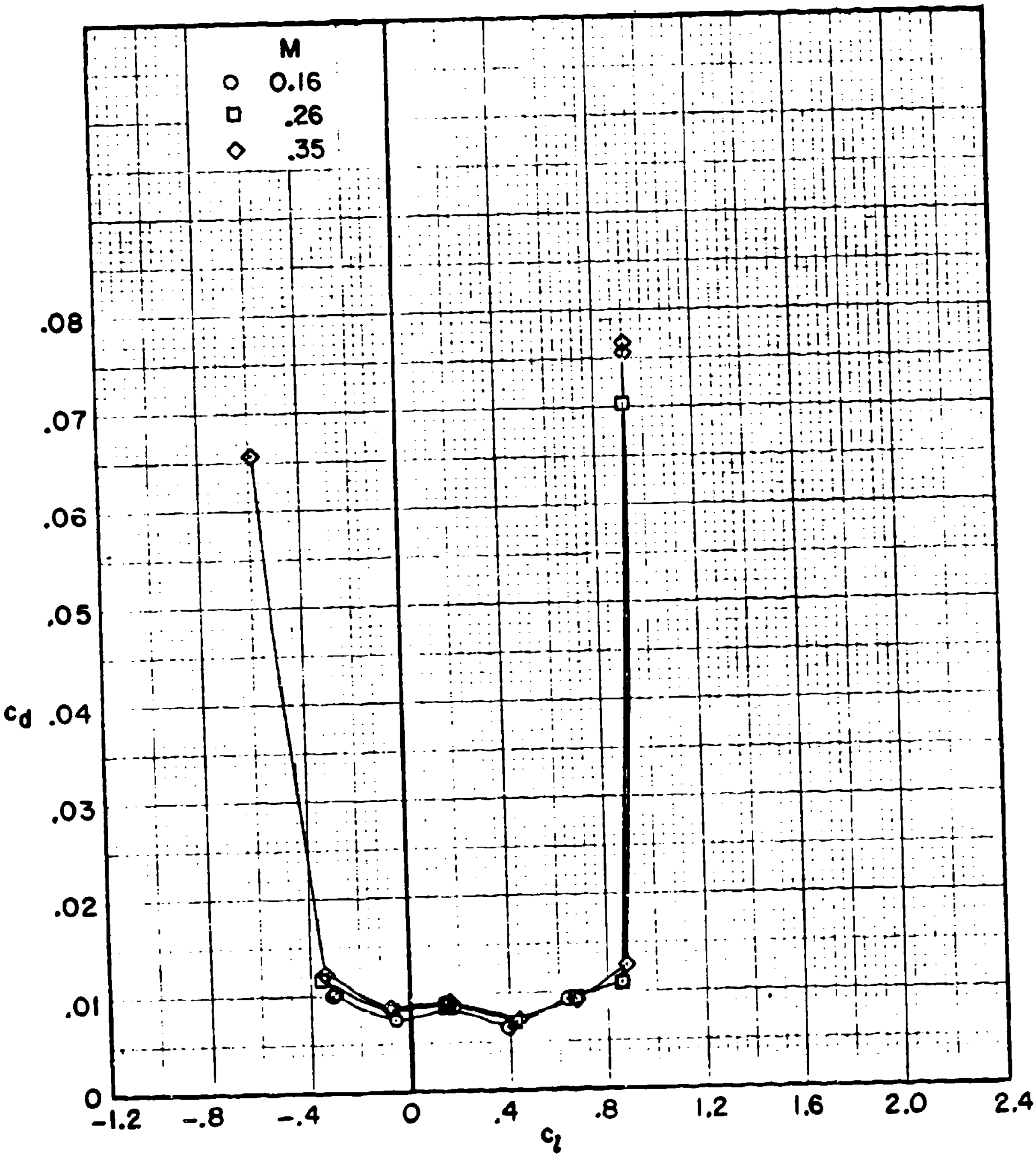


Figure C.4A

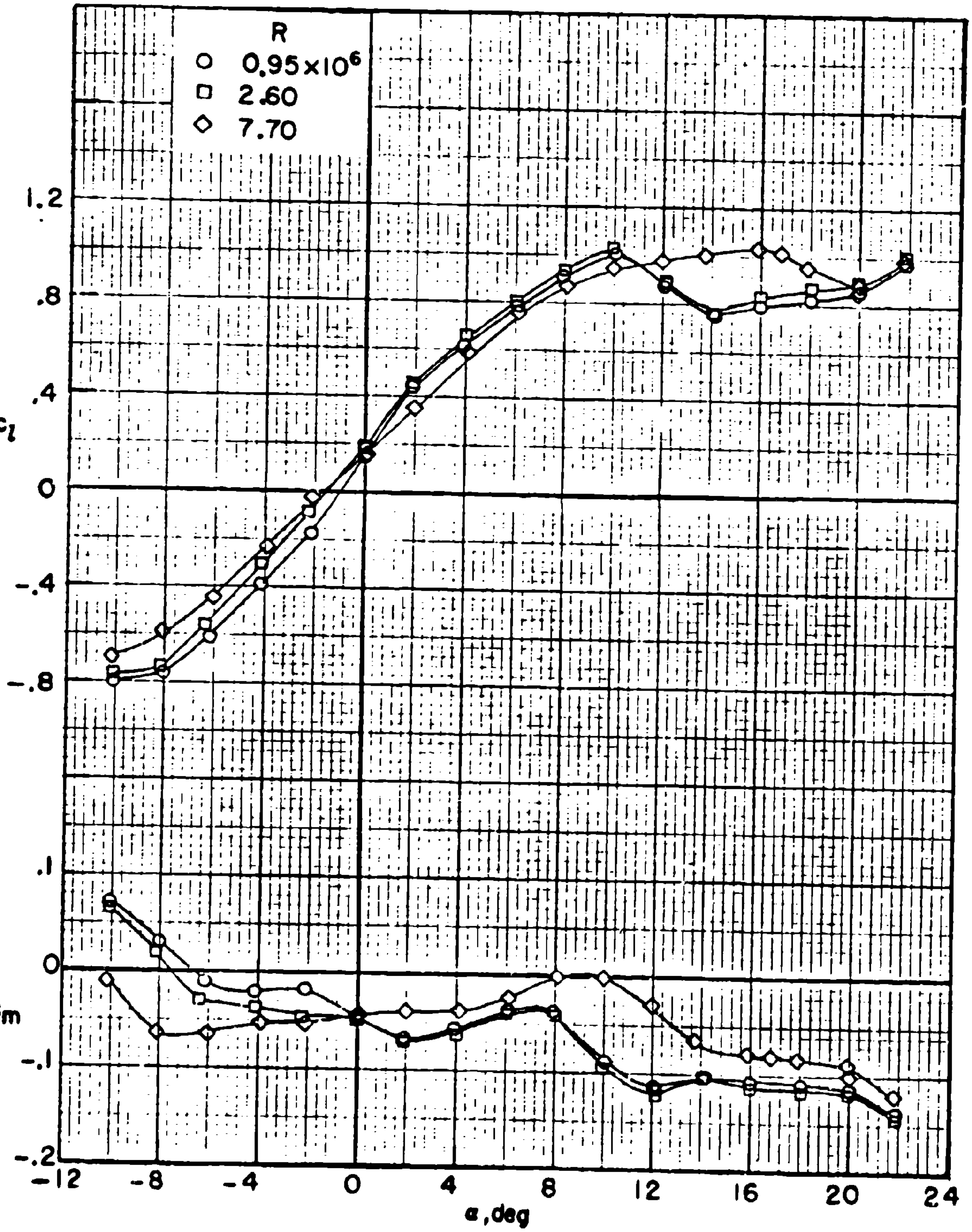
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. R = 2.6 x 106, MODEL SMOOTH



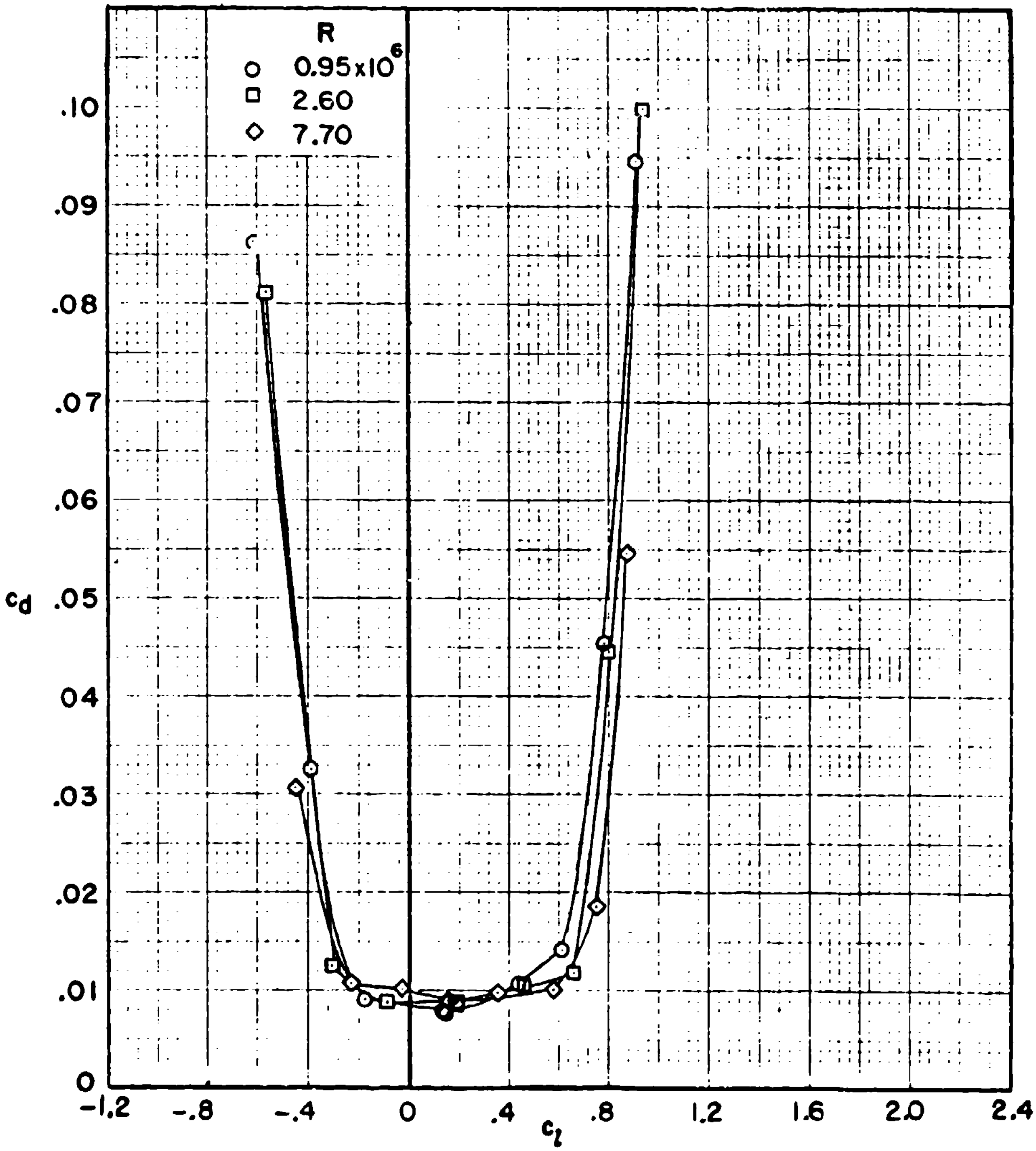
TWO DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. $R = 2.6 \times 10^6$, MODEL SMOOTH



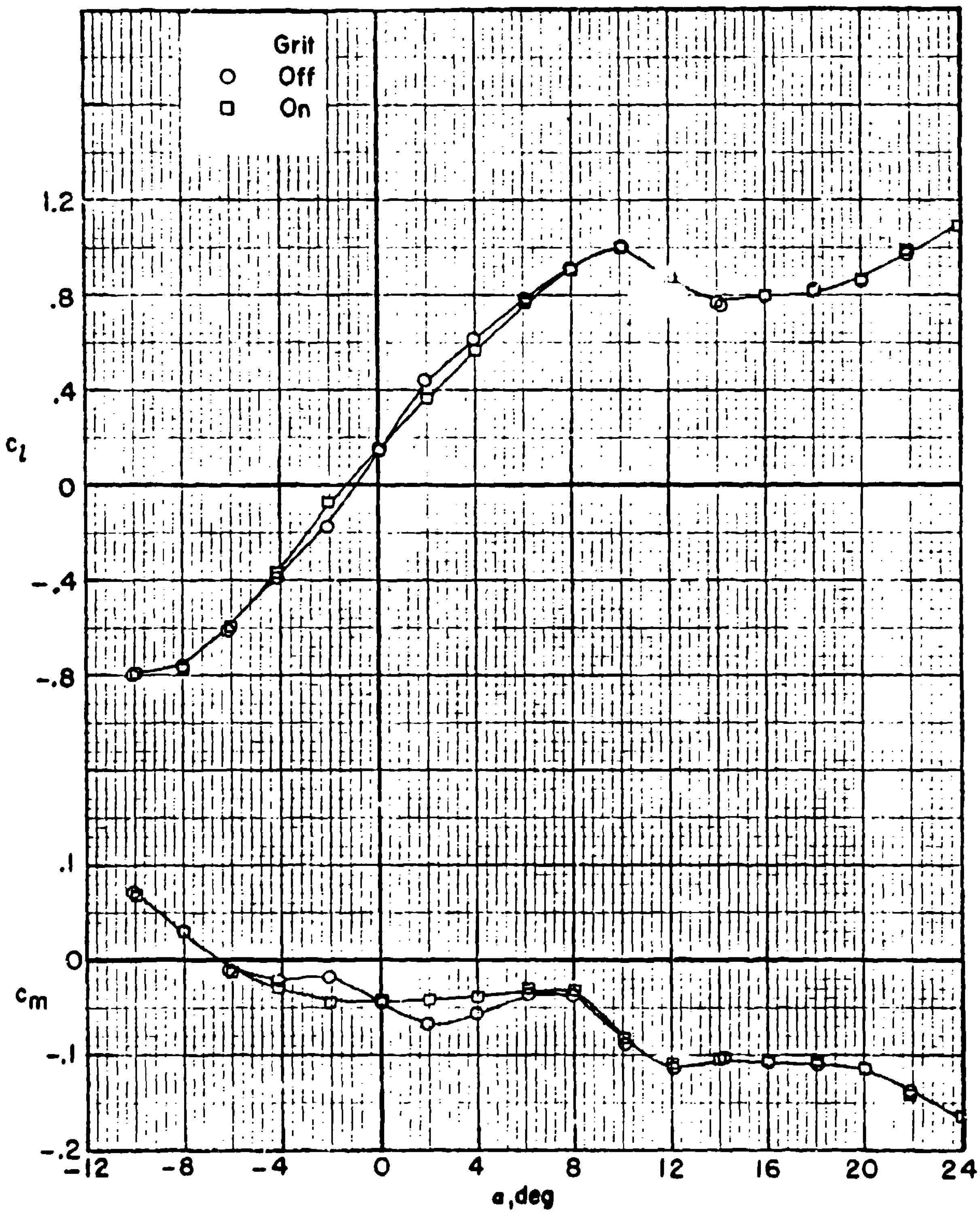
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; MODEL SMOOTH



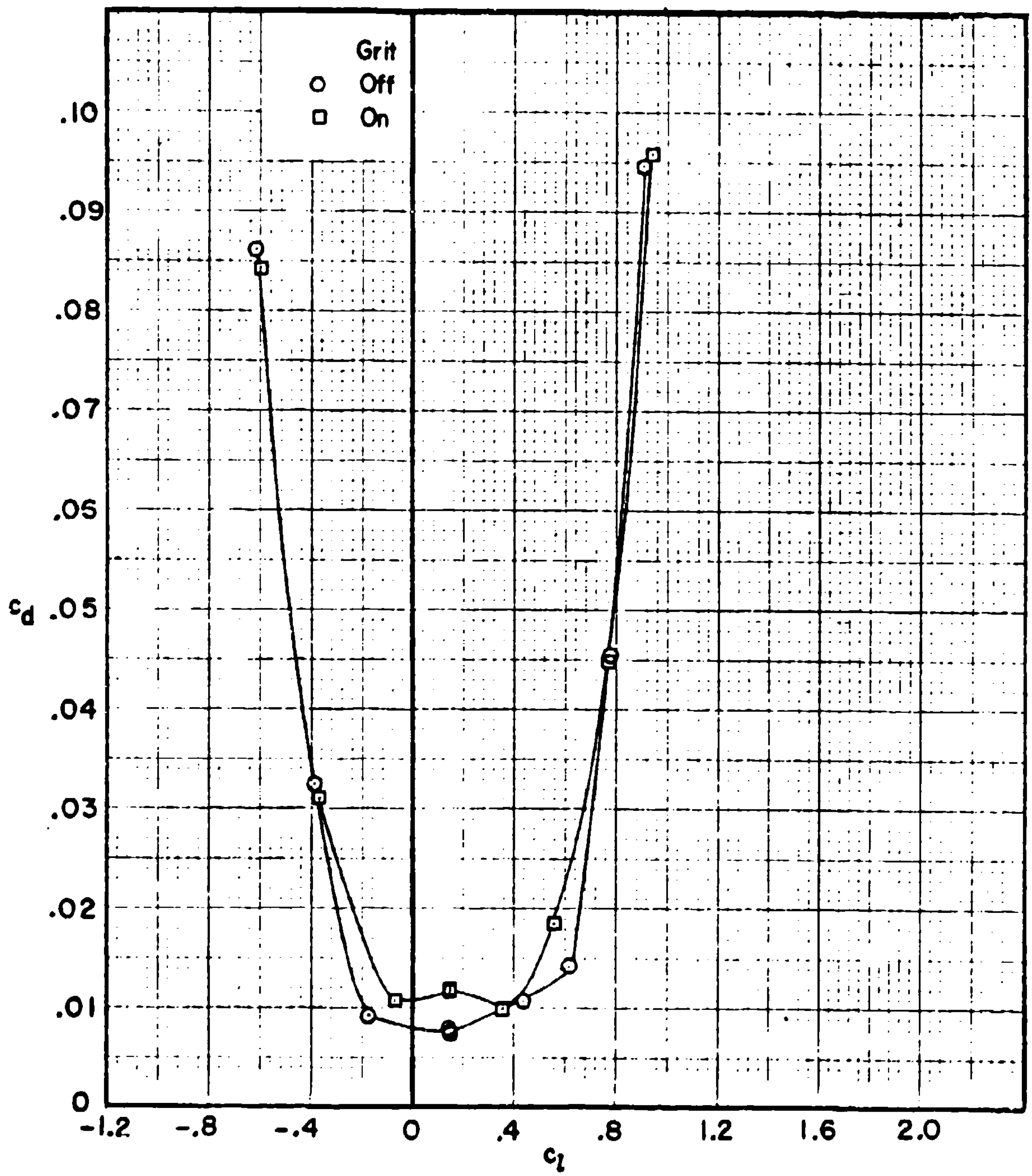
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; MODEL SMOOTH



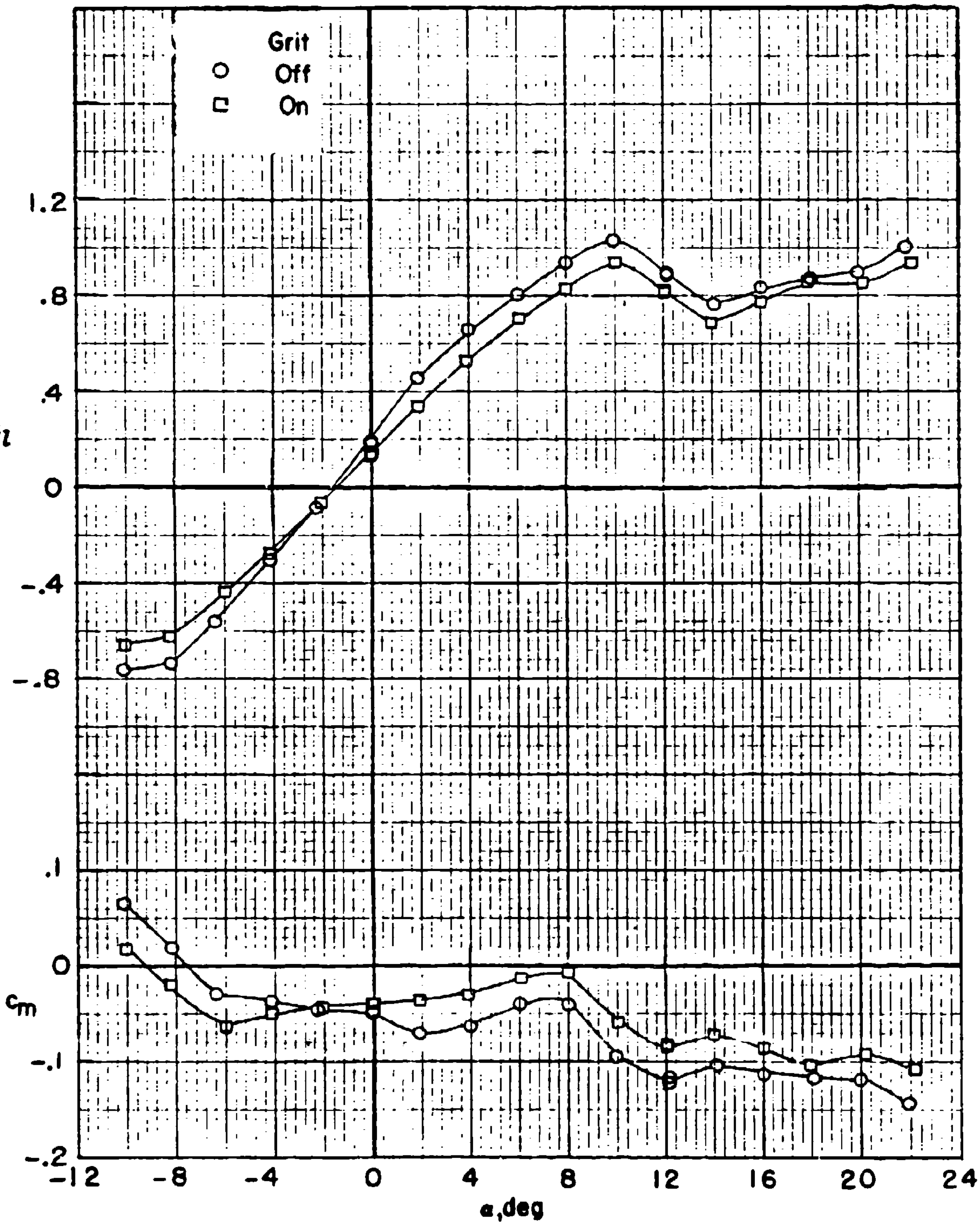
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 0.93 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 0.93 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 2.60 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 2.60 x 10^6

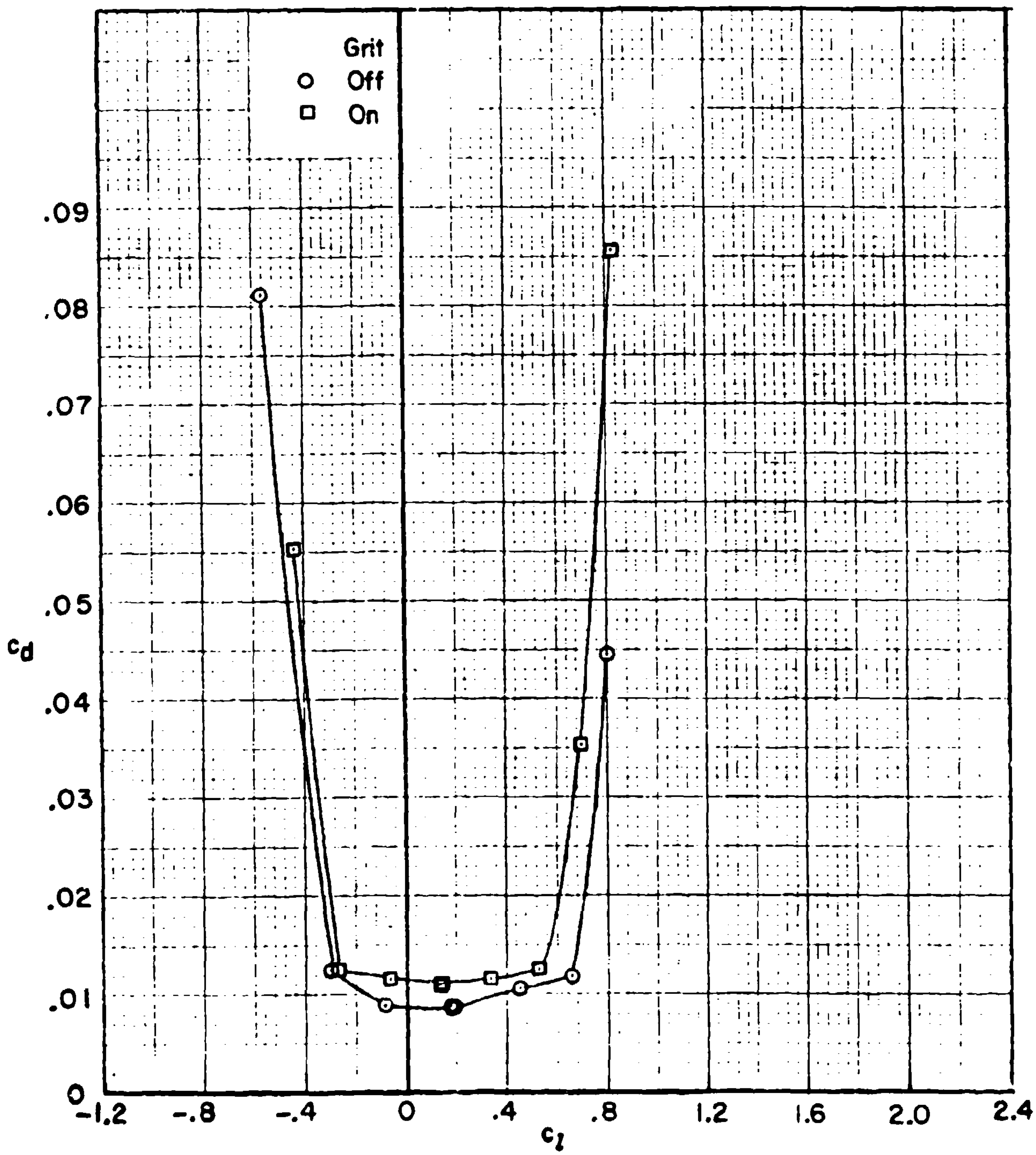
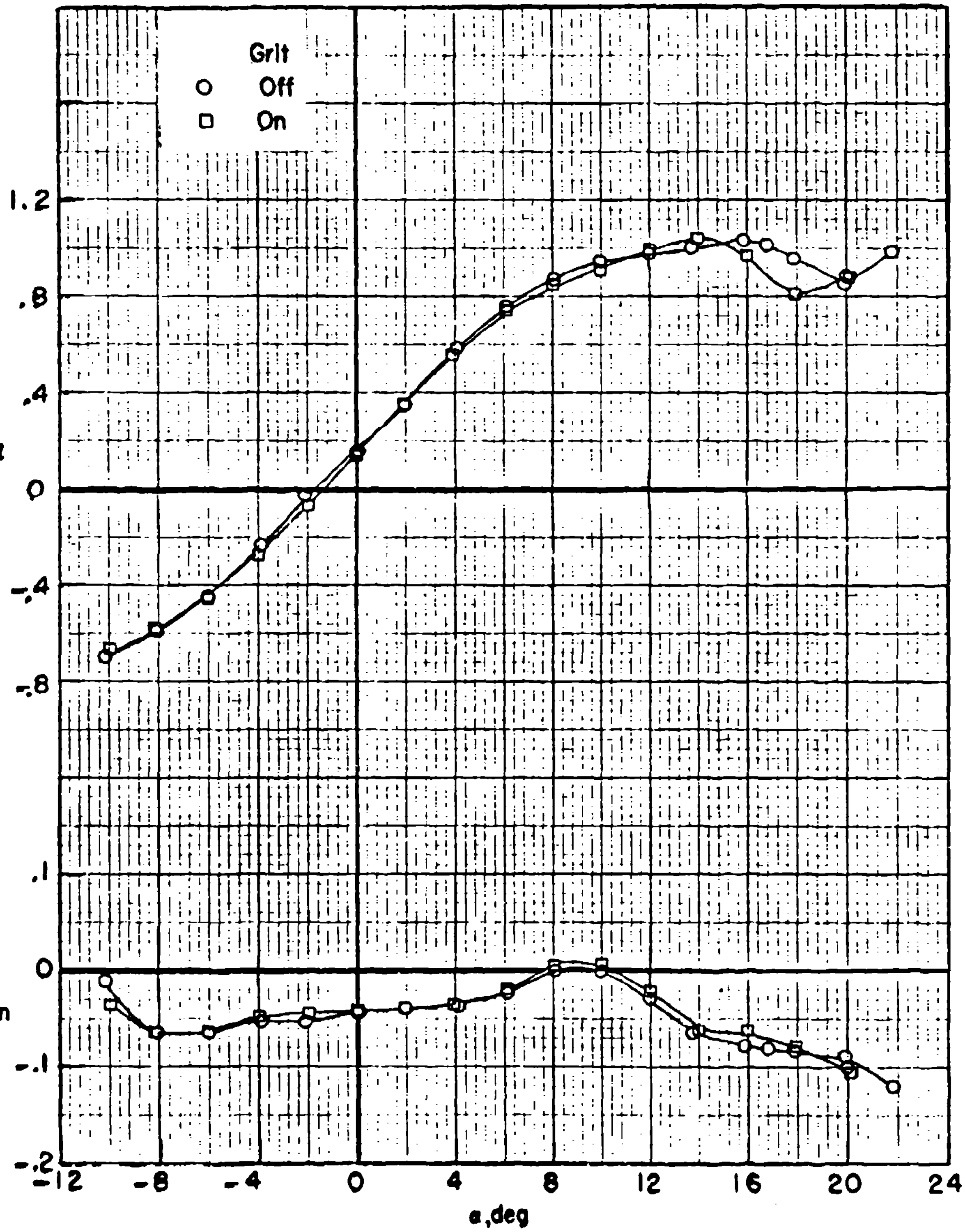


Figure C.8A

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6 PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 7.7 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6 PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 7.7 x 106

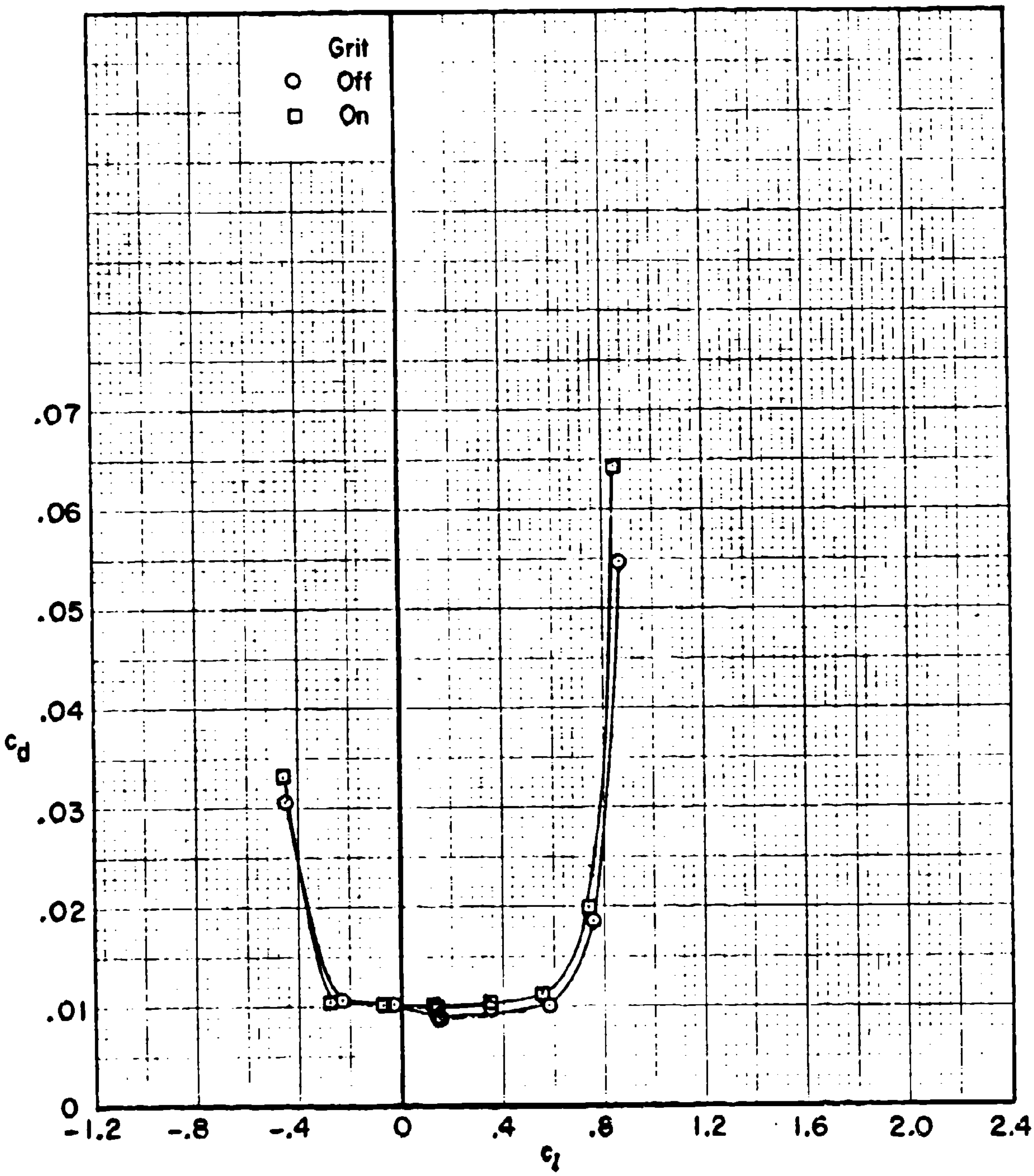
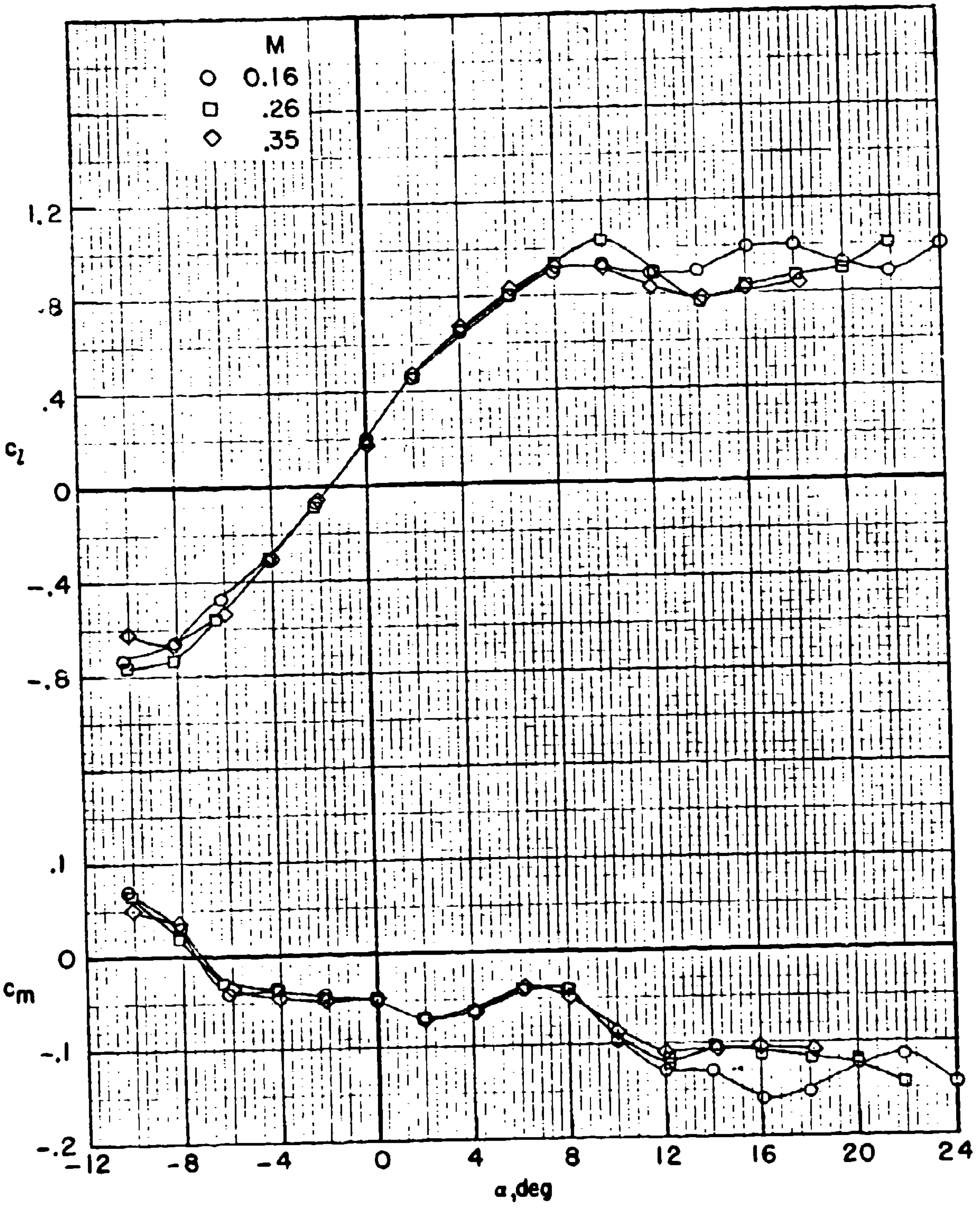
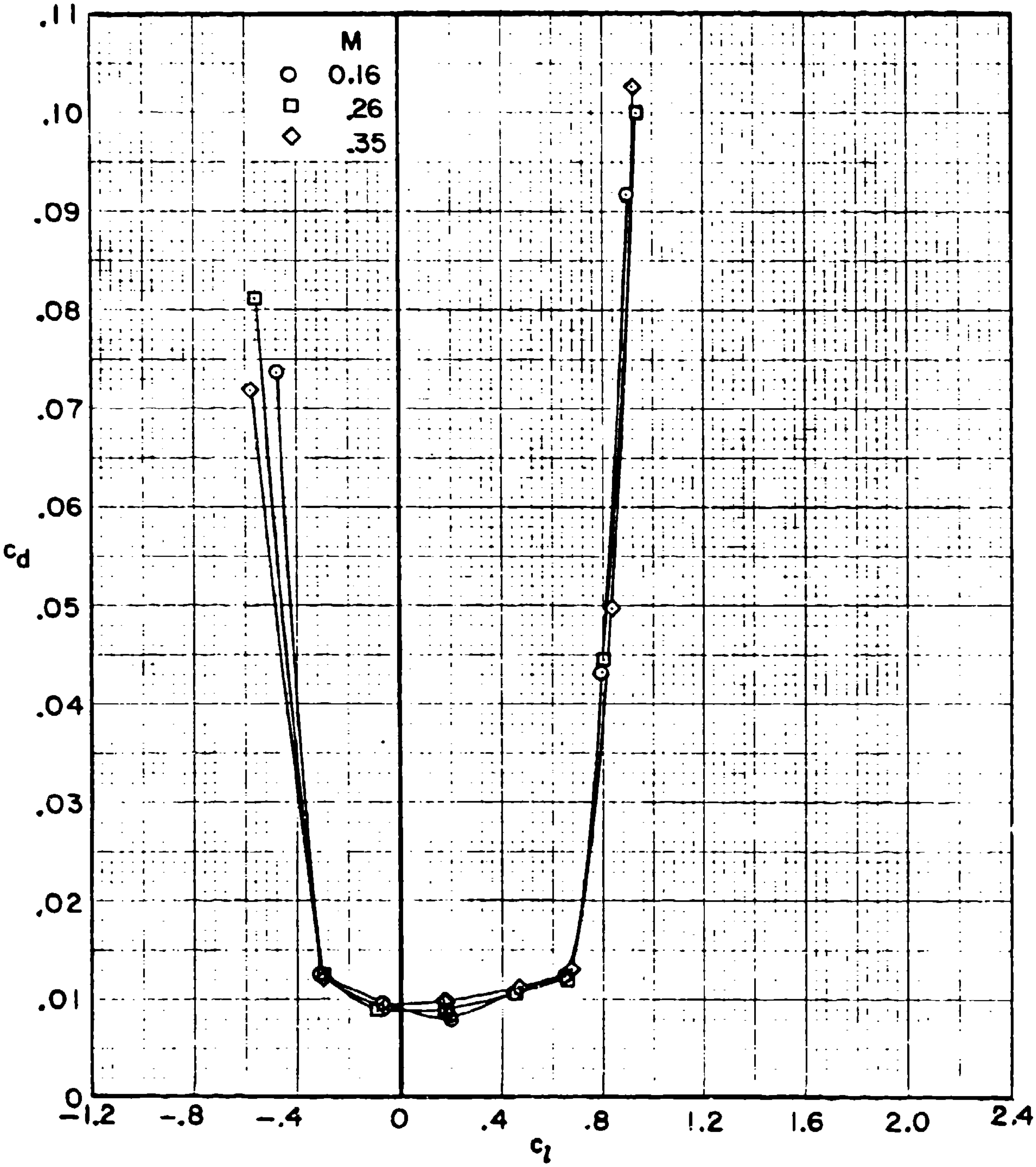


Figure C.9A

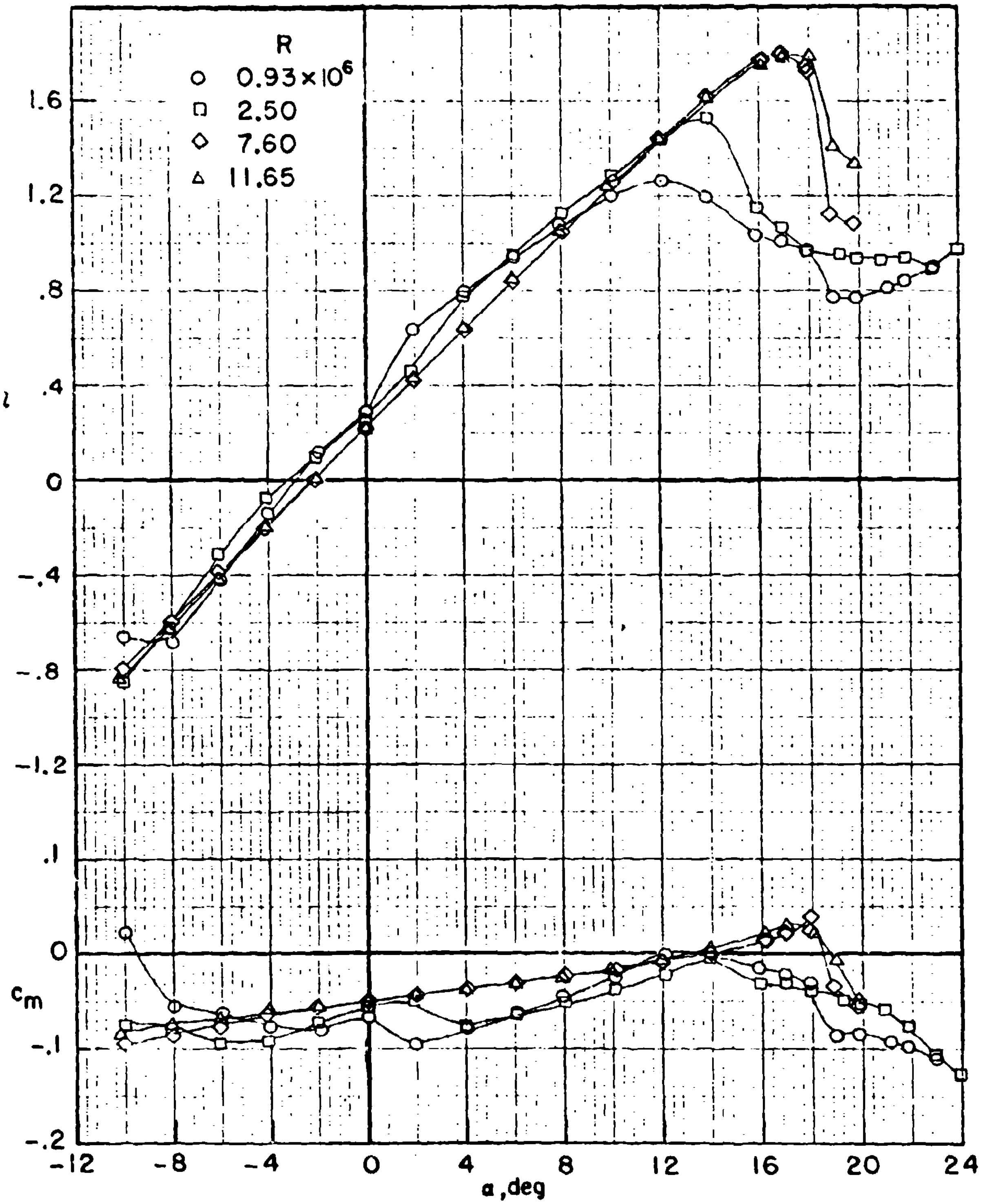
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. R = 2.60 x 10^6; MODEL SMOOTH



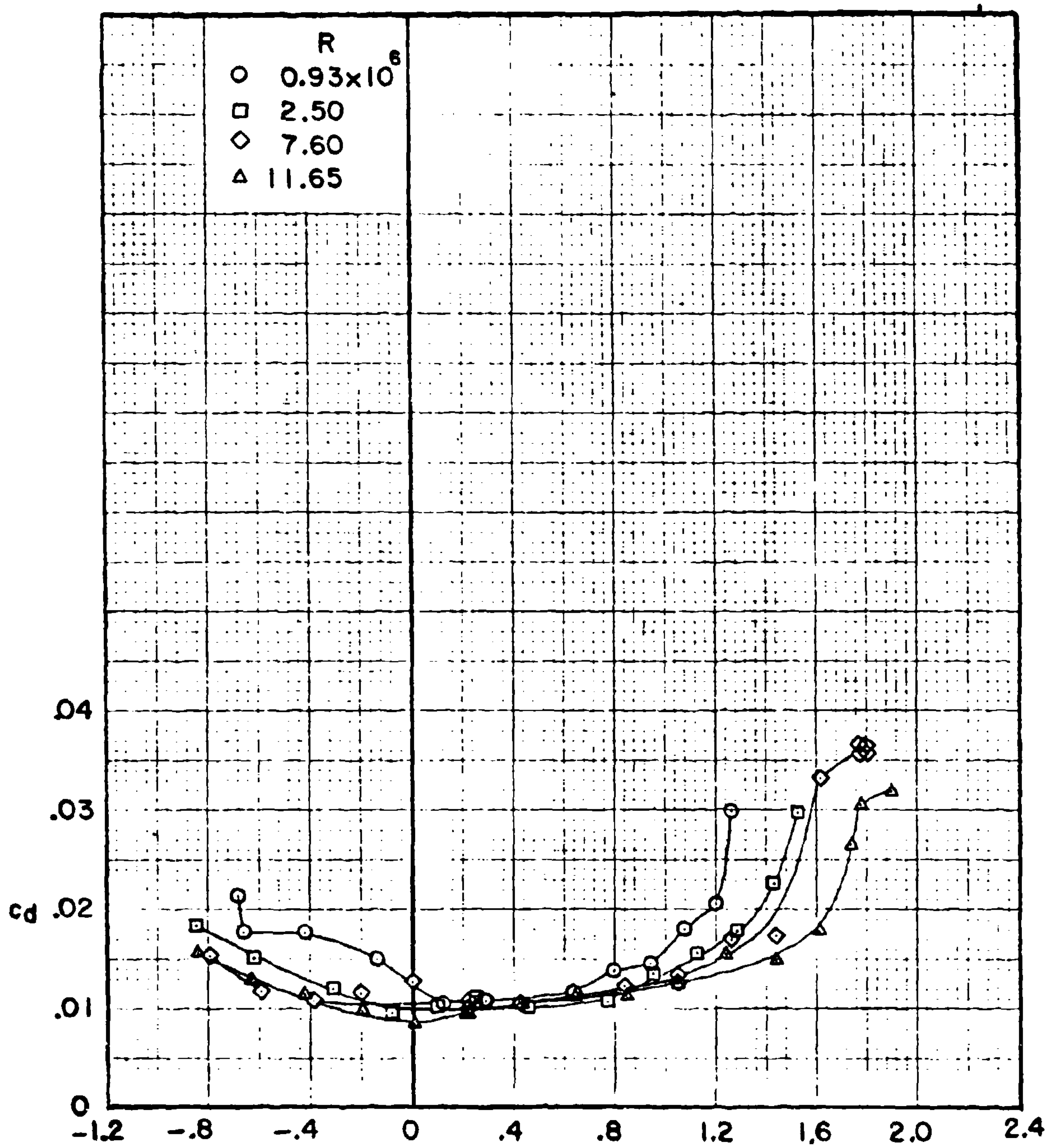
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 6-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. $R = 2.60 \times 10^6$; MODEL SMOOTH



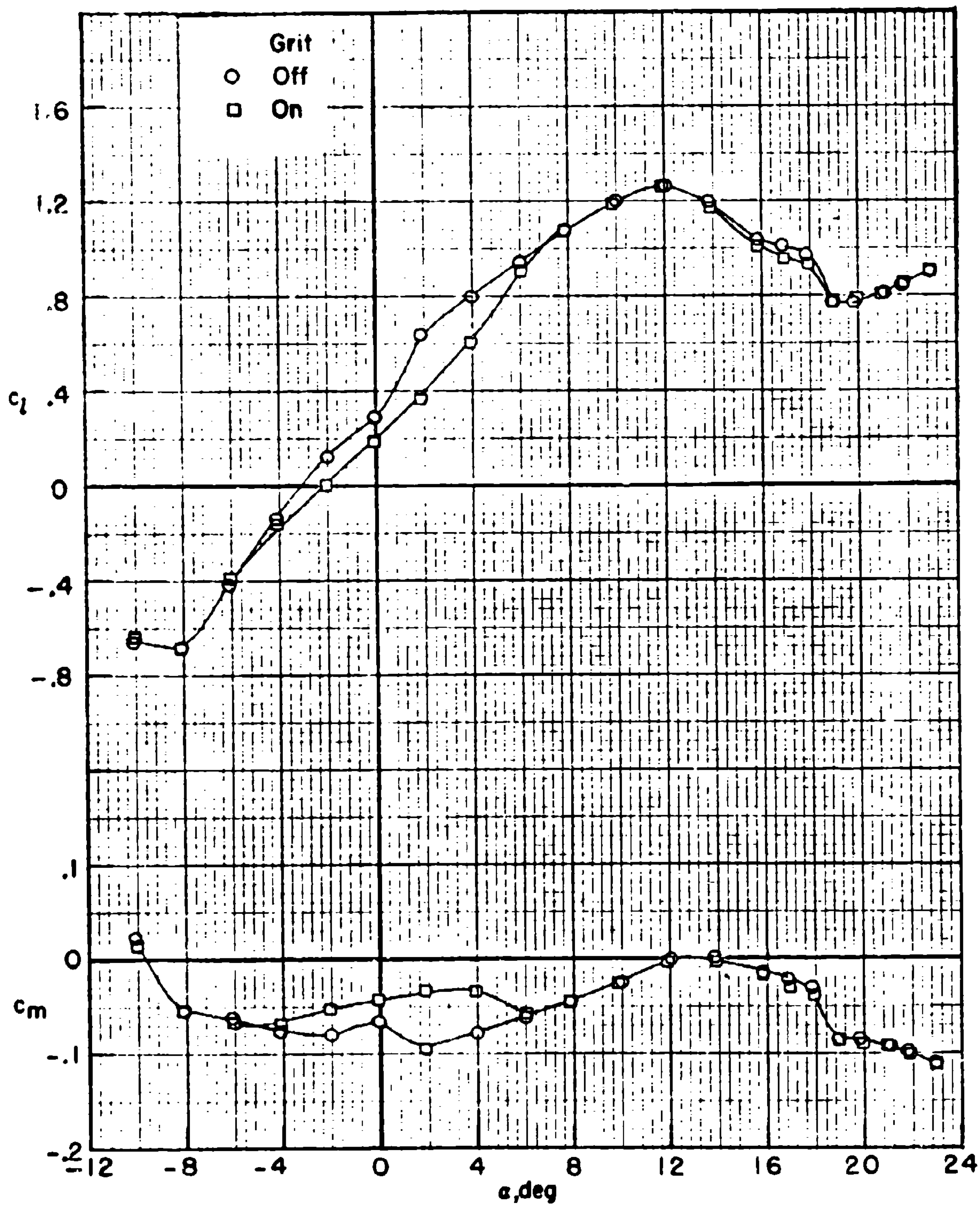
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; MODEL SMOOTH



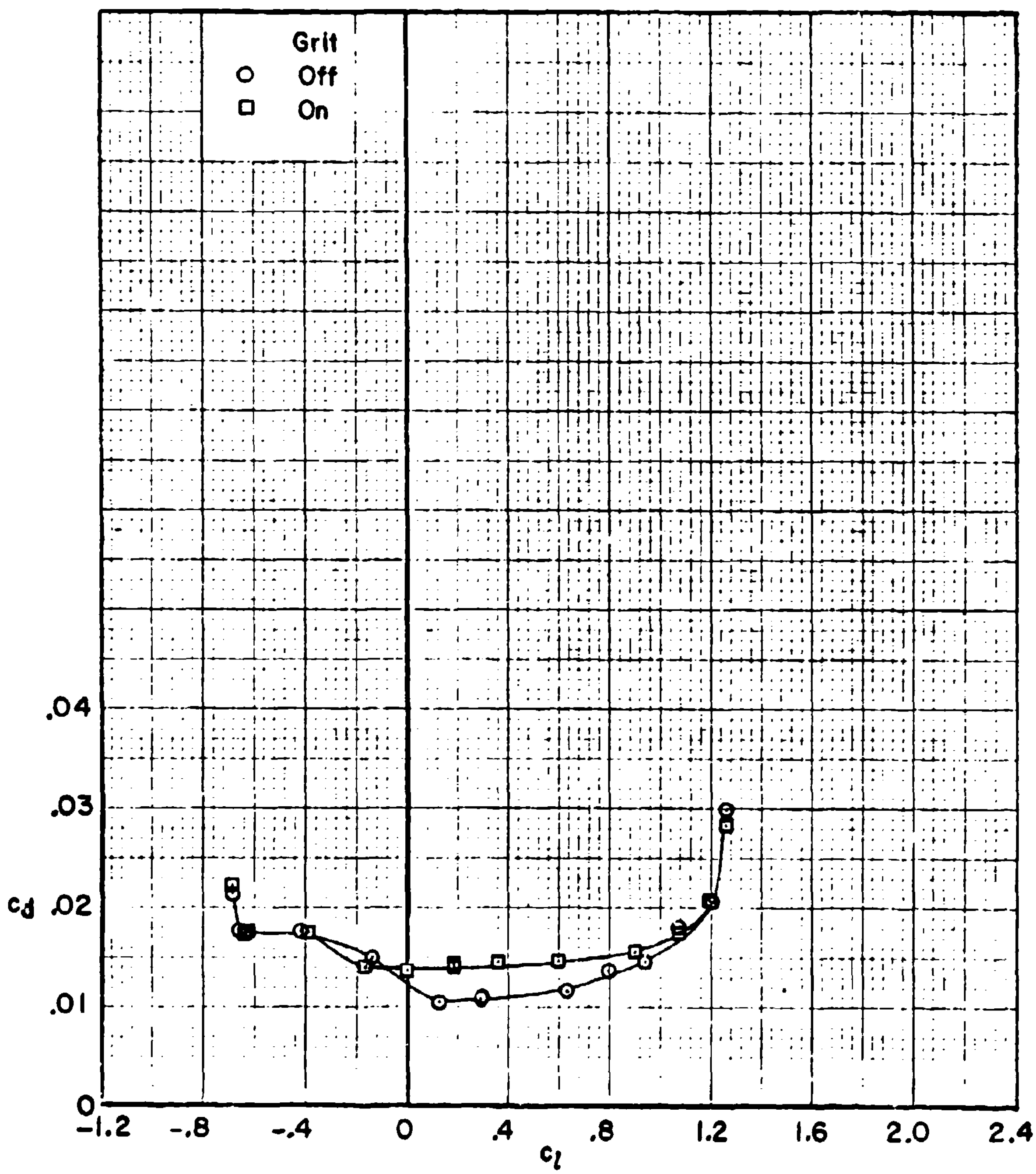
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; MODEL SMOOTH



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 0.93 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 0.93 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. $M = 0.26$; $R = 2.5 \times 10^6$

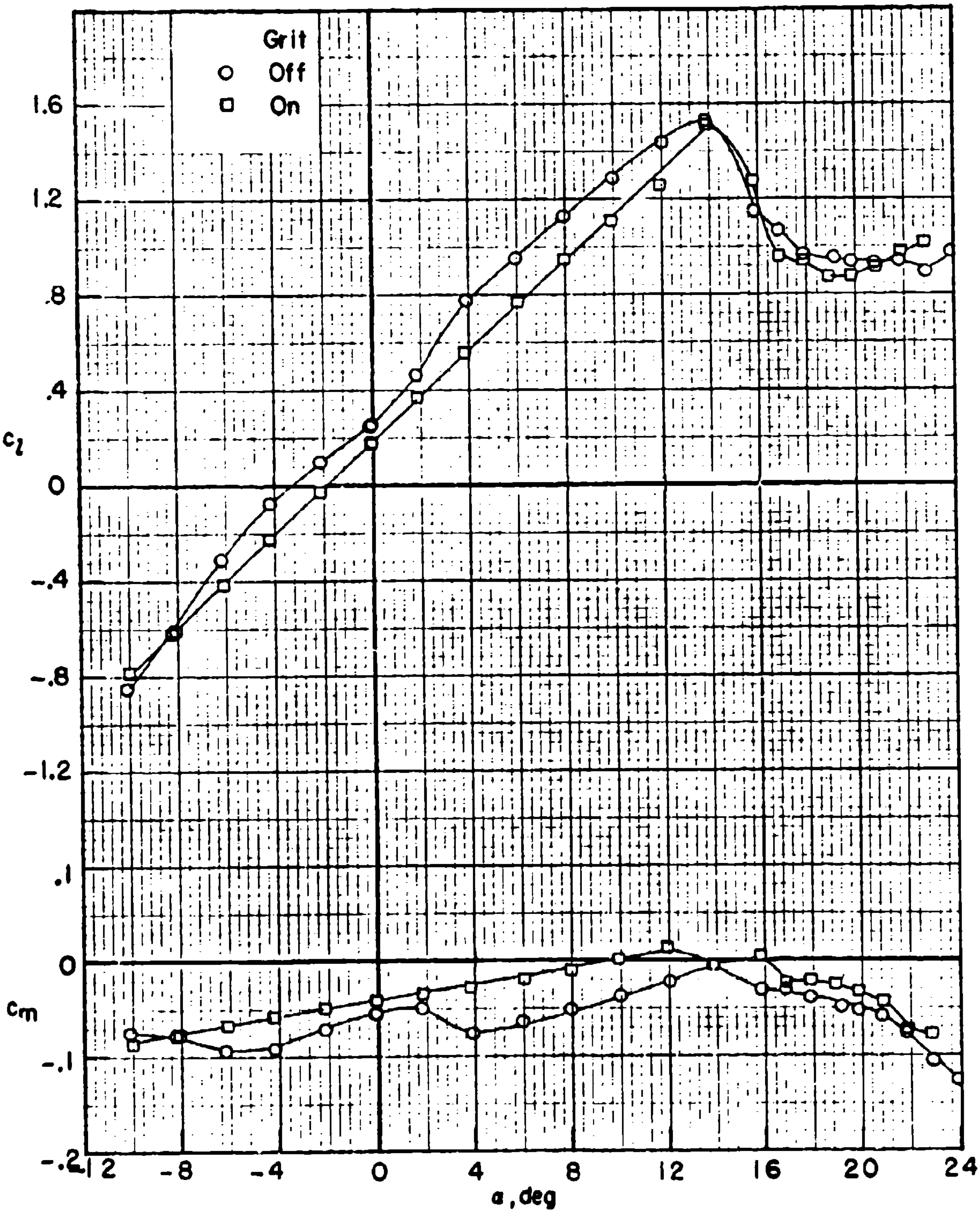
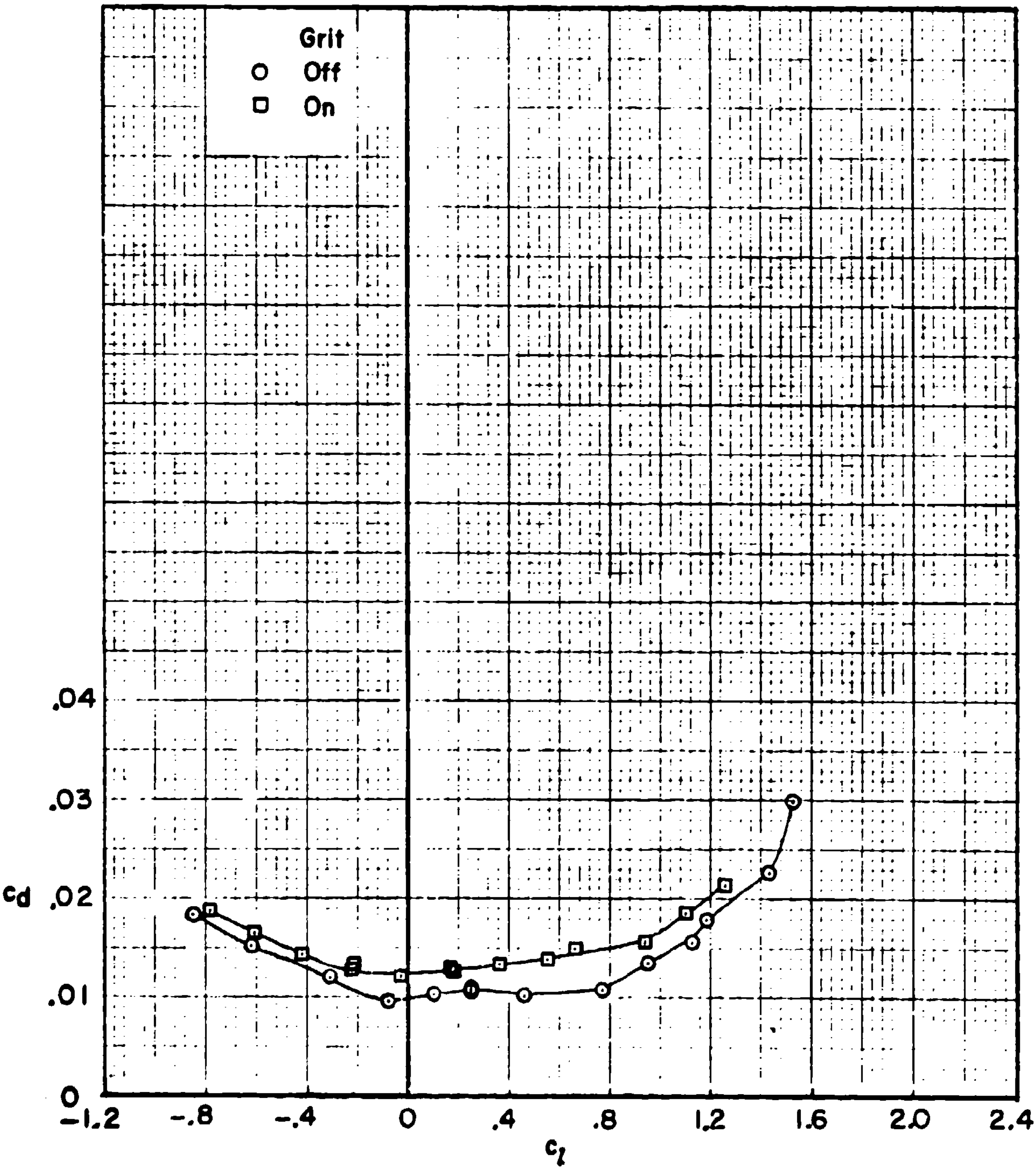
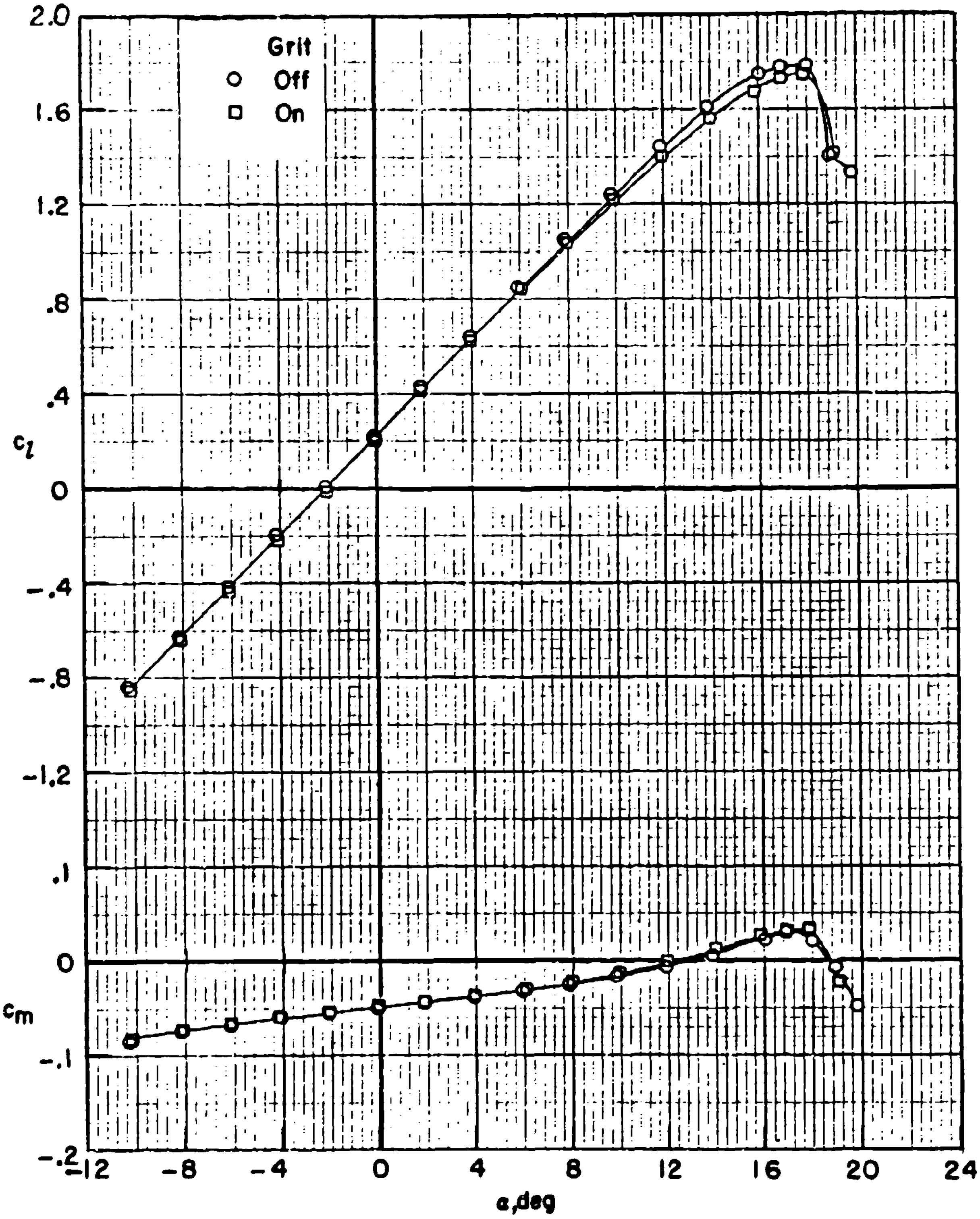


Figure C.12B

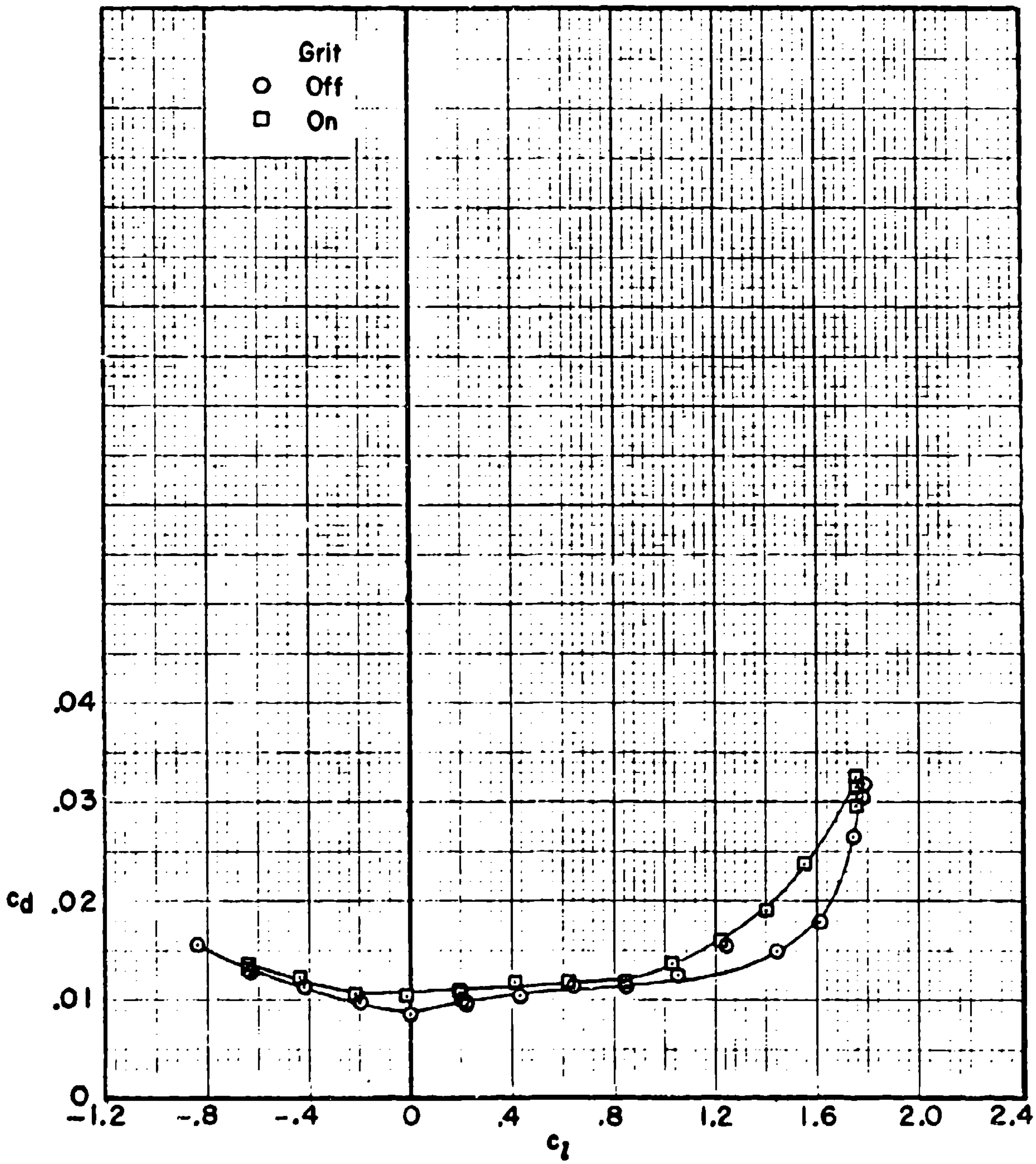
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 2.5 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 11.65 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 11.65 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. R = 2.50 x 10^6; MODEL SMOOTH

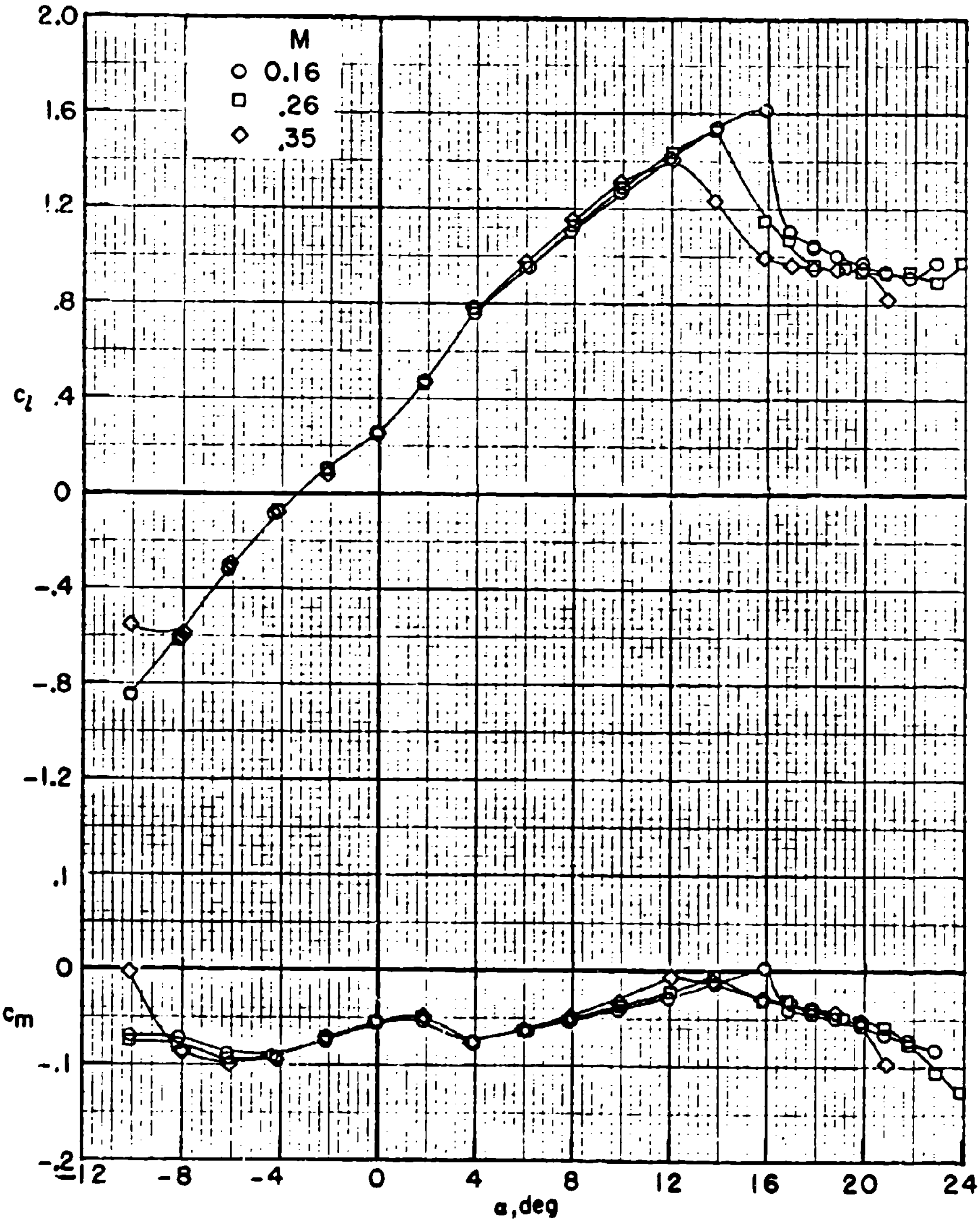
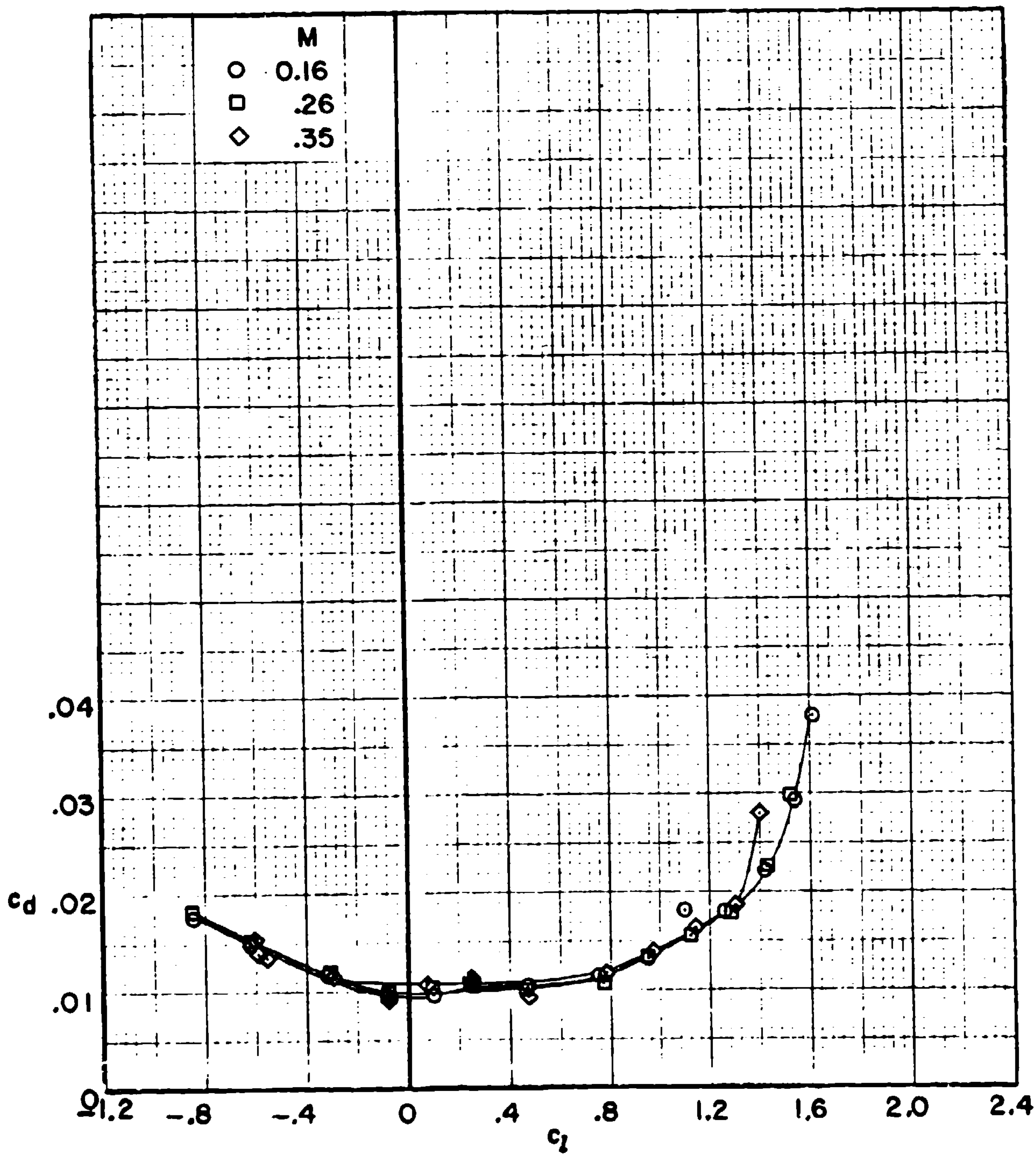


Figure C.14B

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. R = 2.50 x 10^6; MODEL SMOOTH



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; MODEL SMOOTH

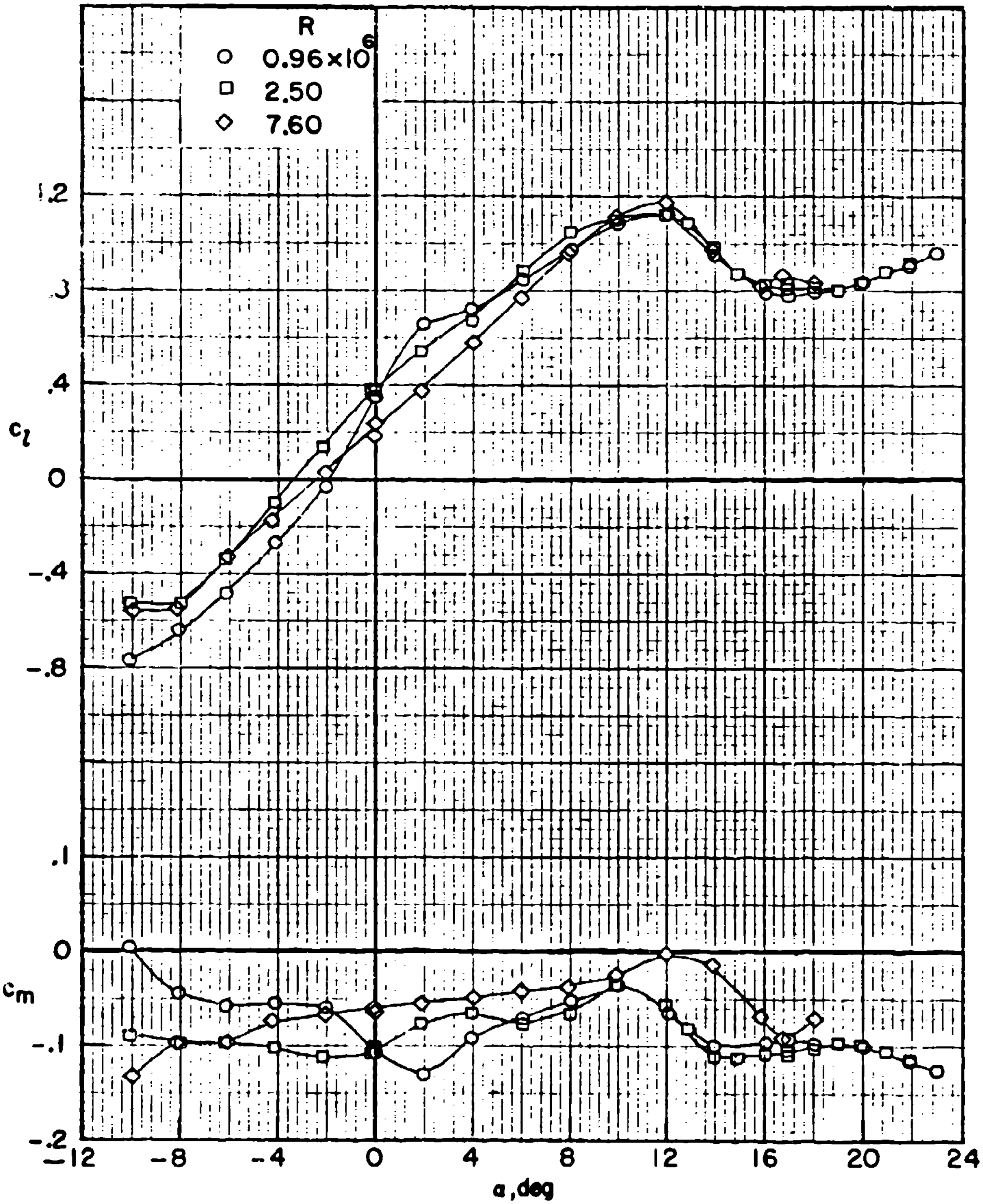


Figure C.15B

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; MODEL SMOOTH

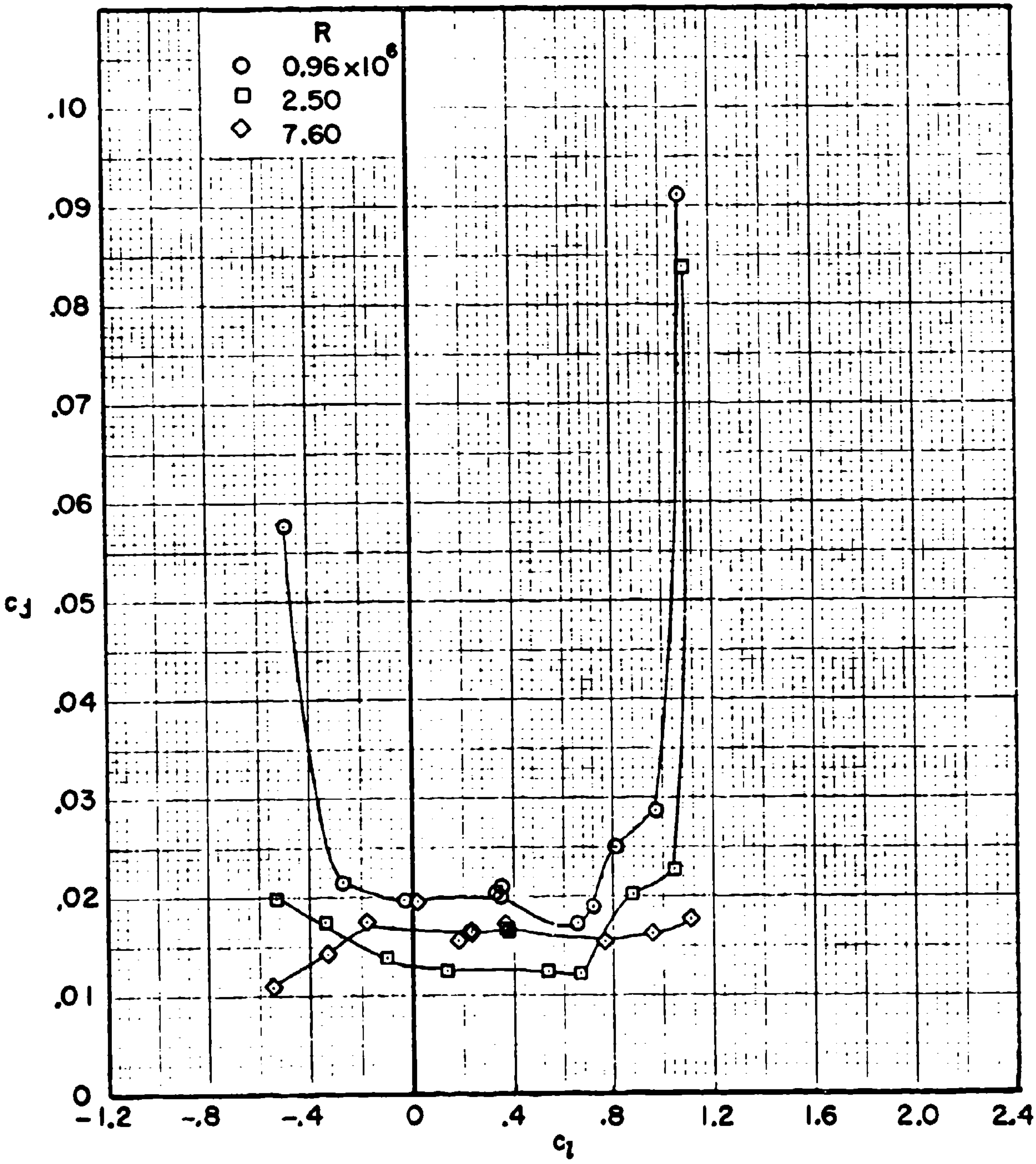
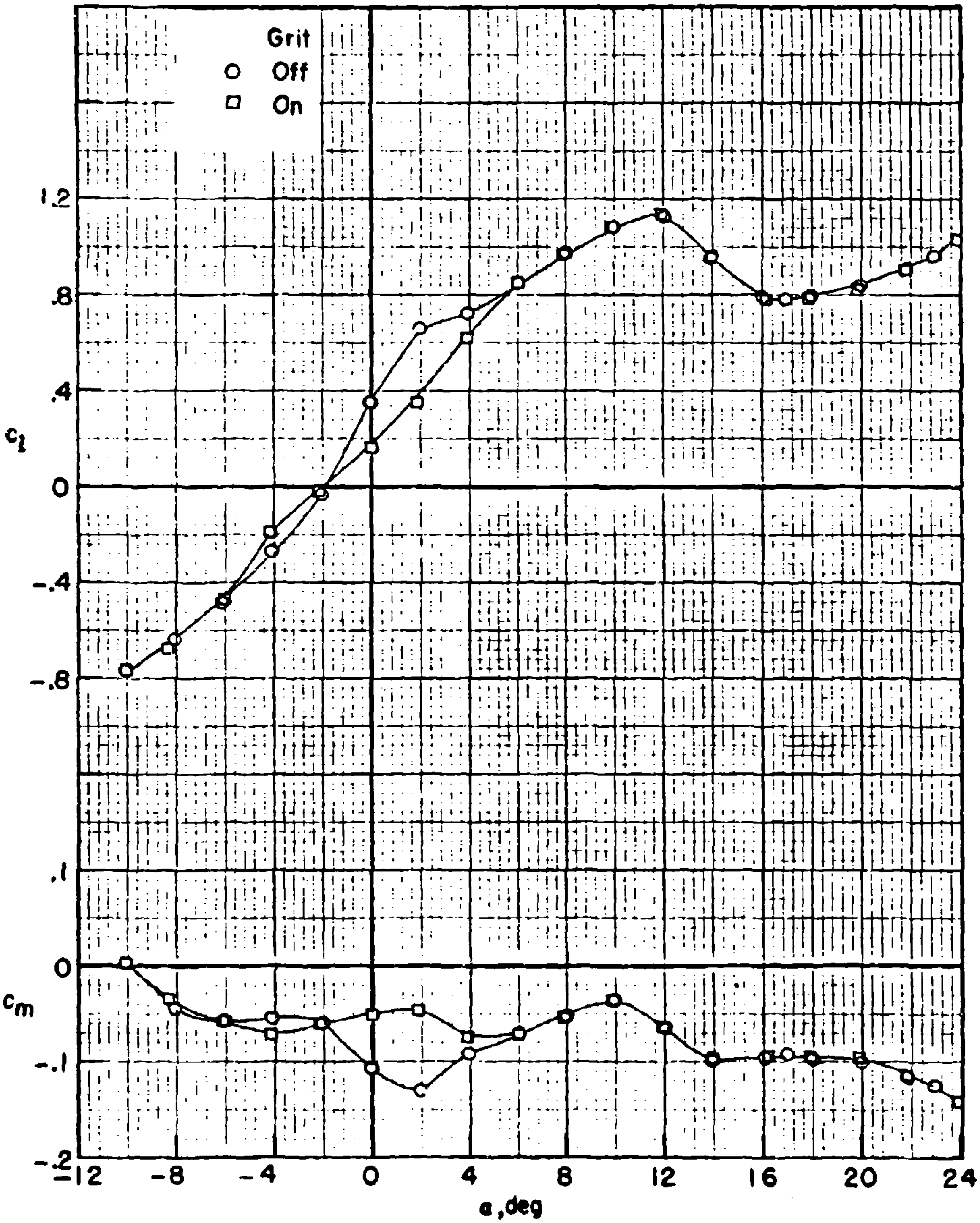


Figure C.16A

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 0.96 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 0.96 x 10^6

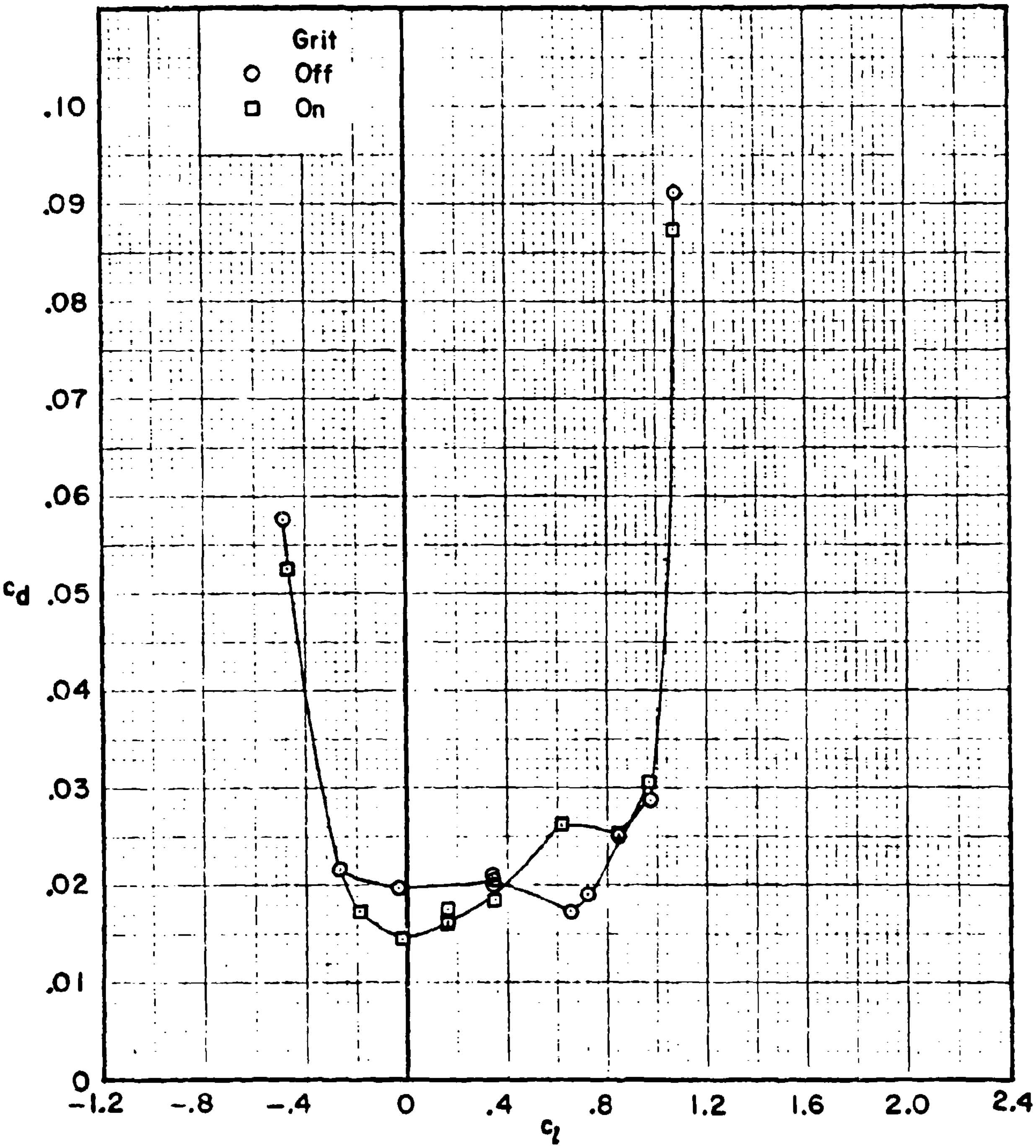


Figure C.17A

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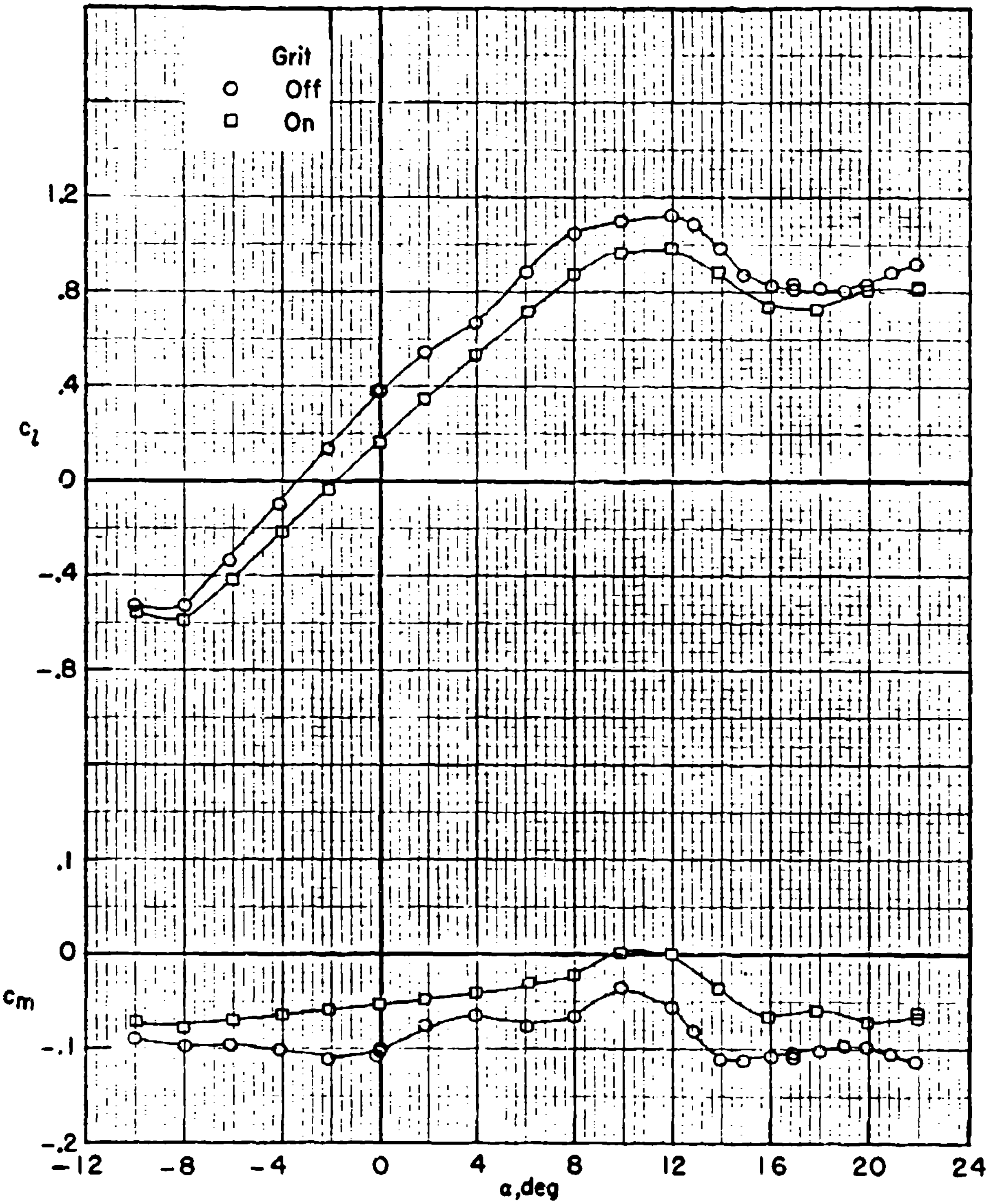
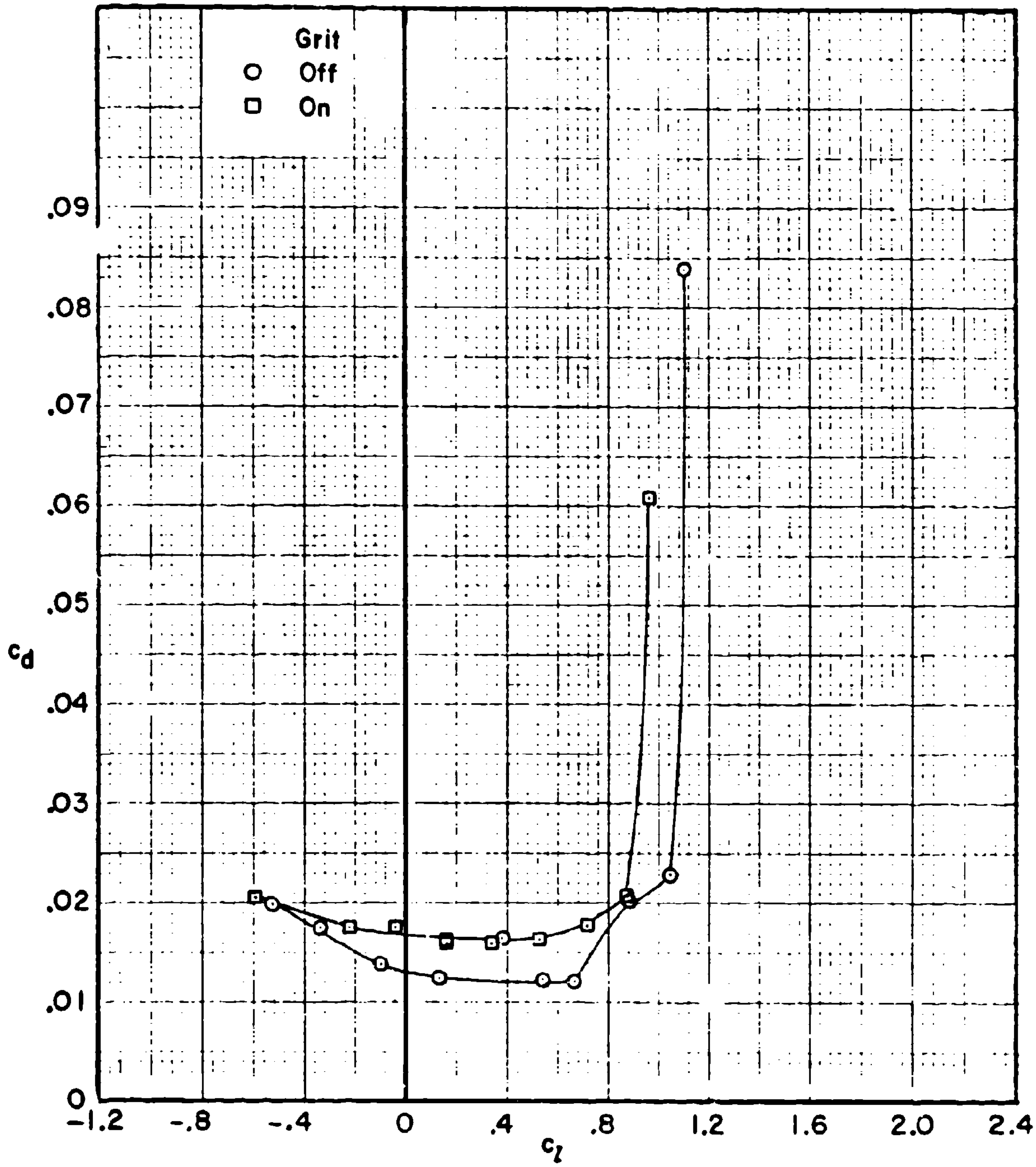
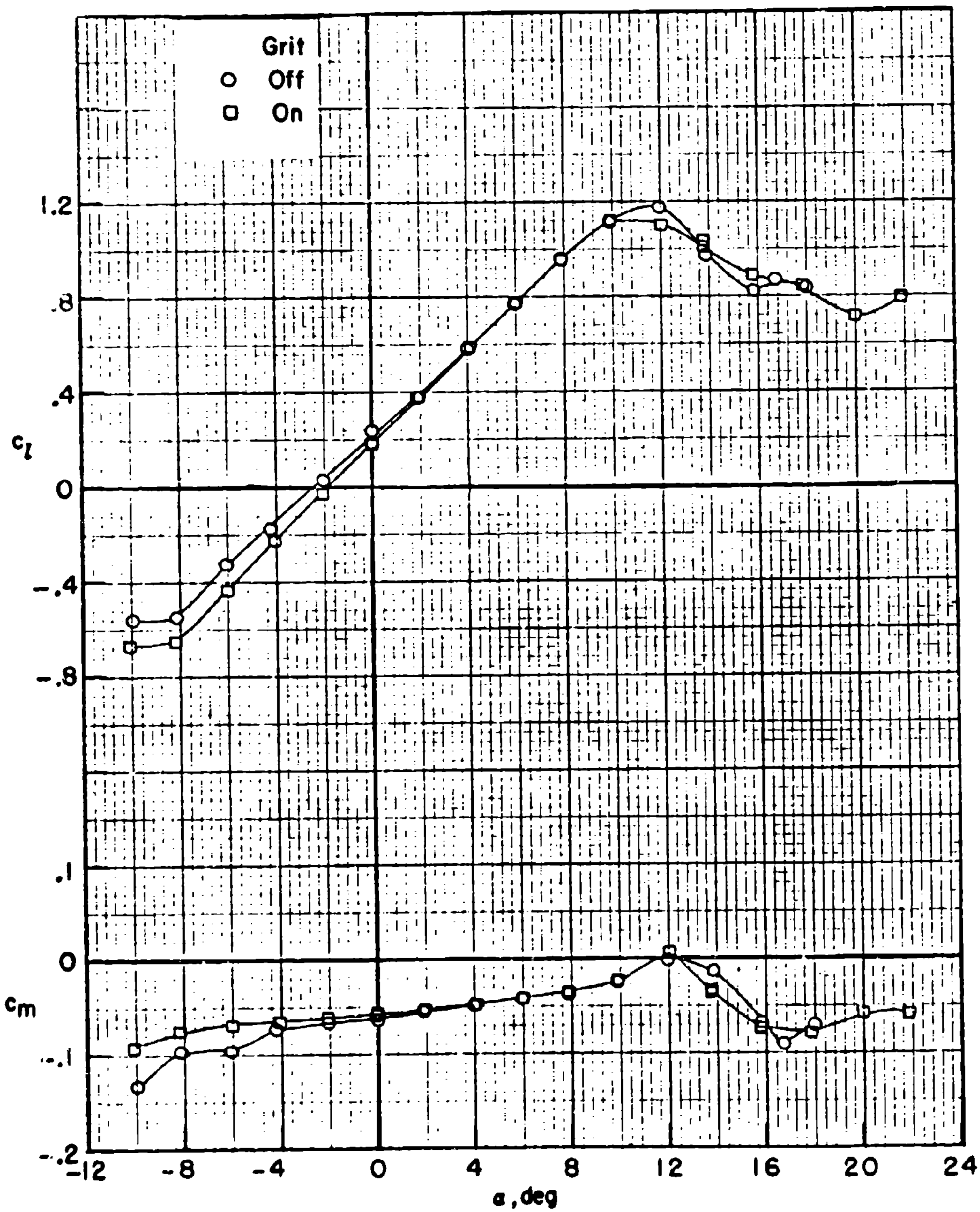
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 2.50 x 10^6



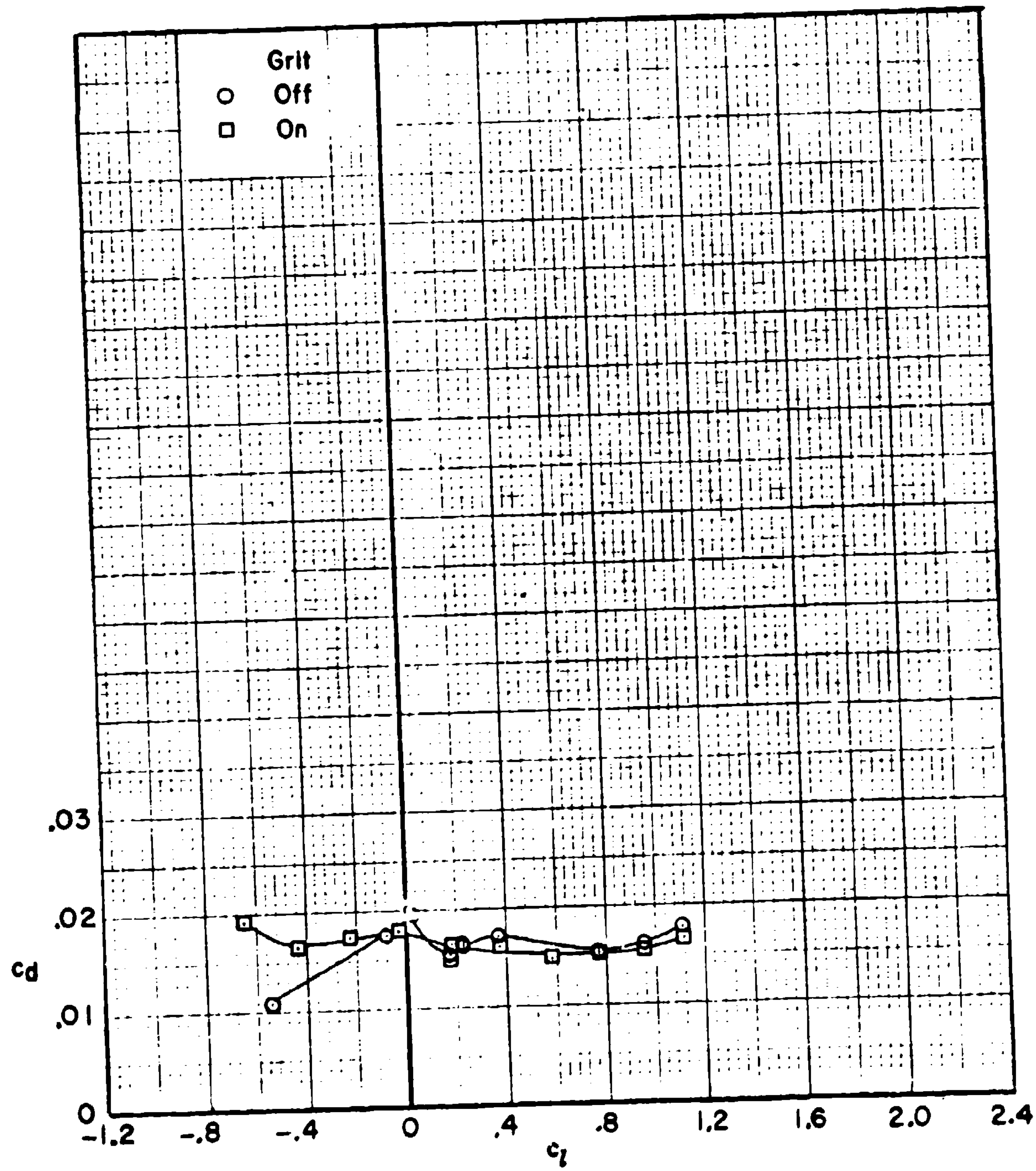
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. $M = 0.26$; $R = 2.50 \times 10^6$



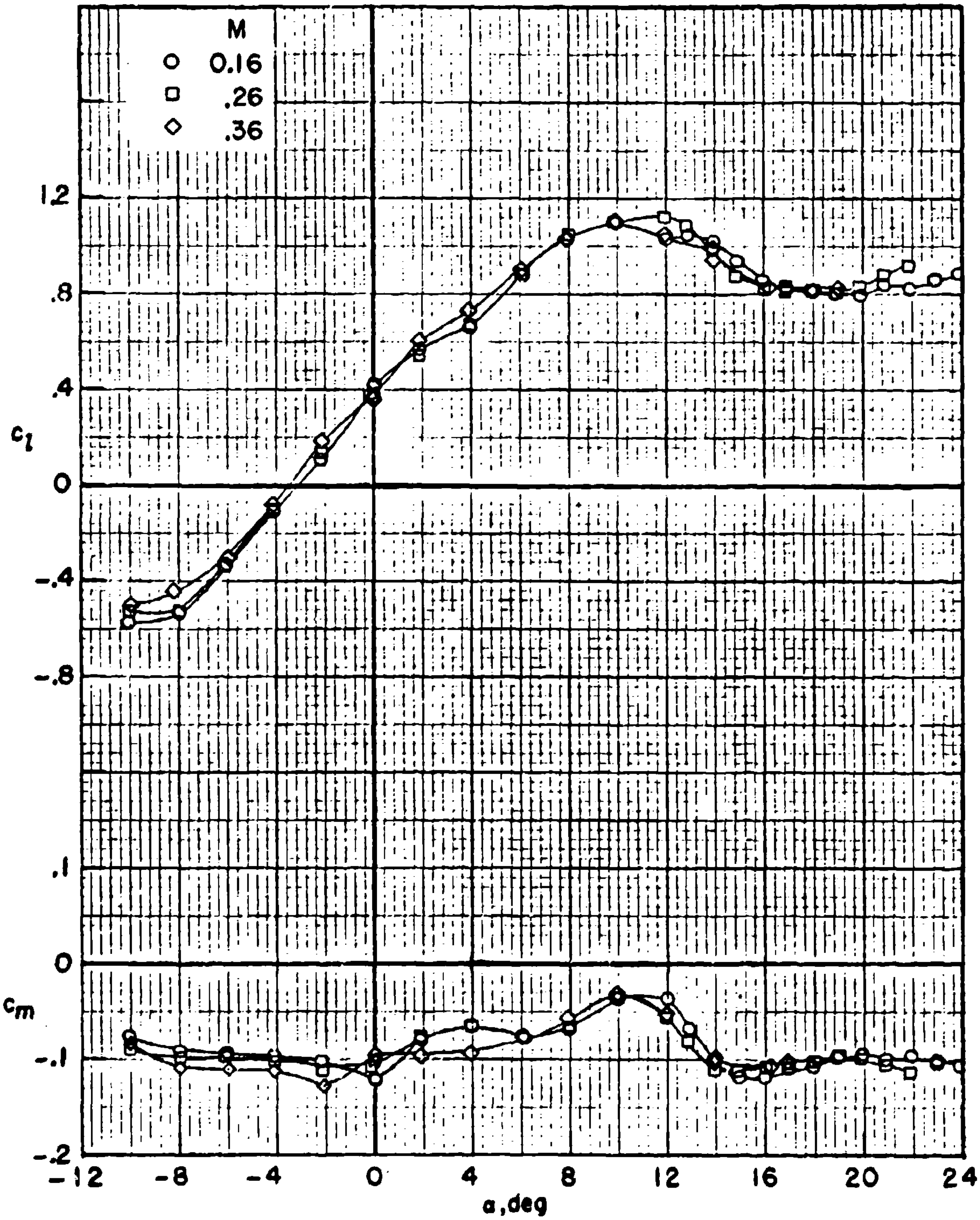
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 7.60 x 10^6



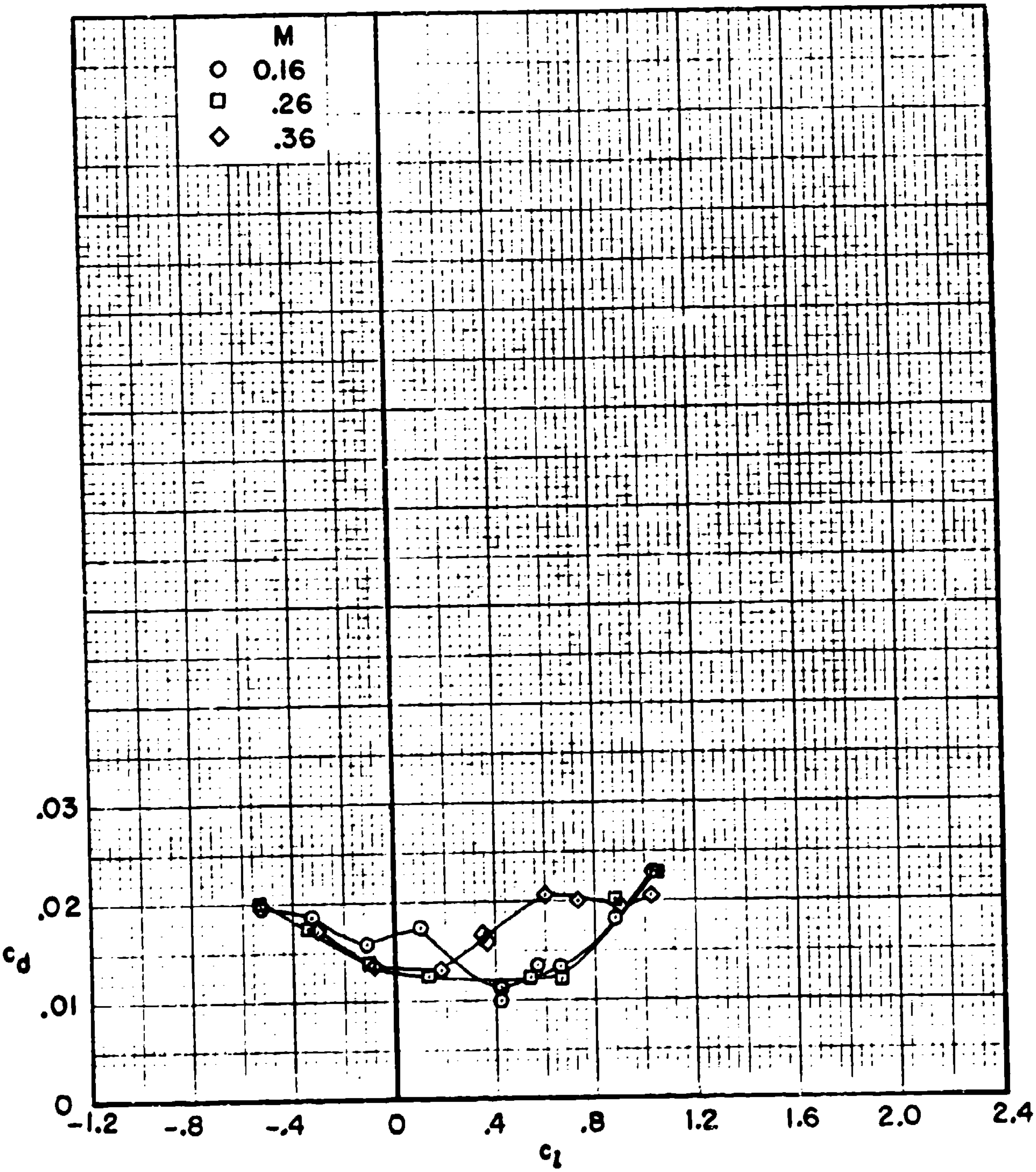
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. $M = 0.26$; $R = 7.60 \times 10^6$



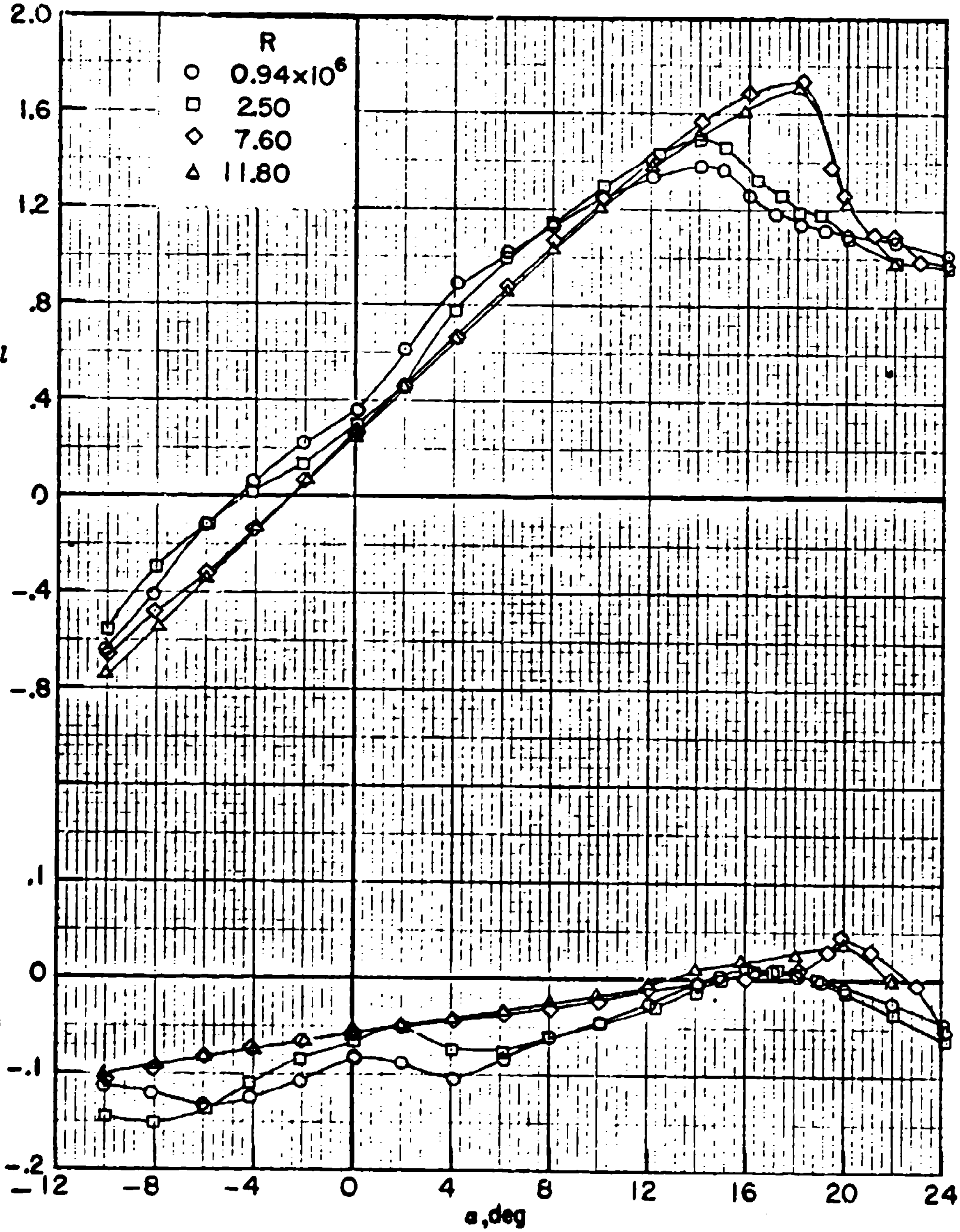
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. R = 2.56 x 10^6; MODEL SMOOTH



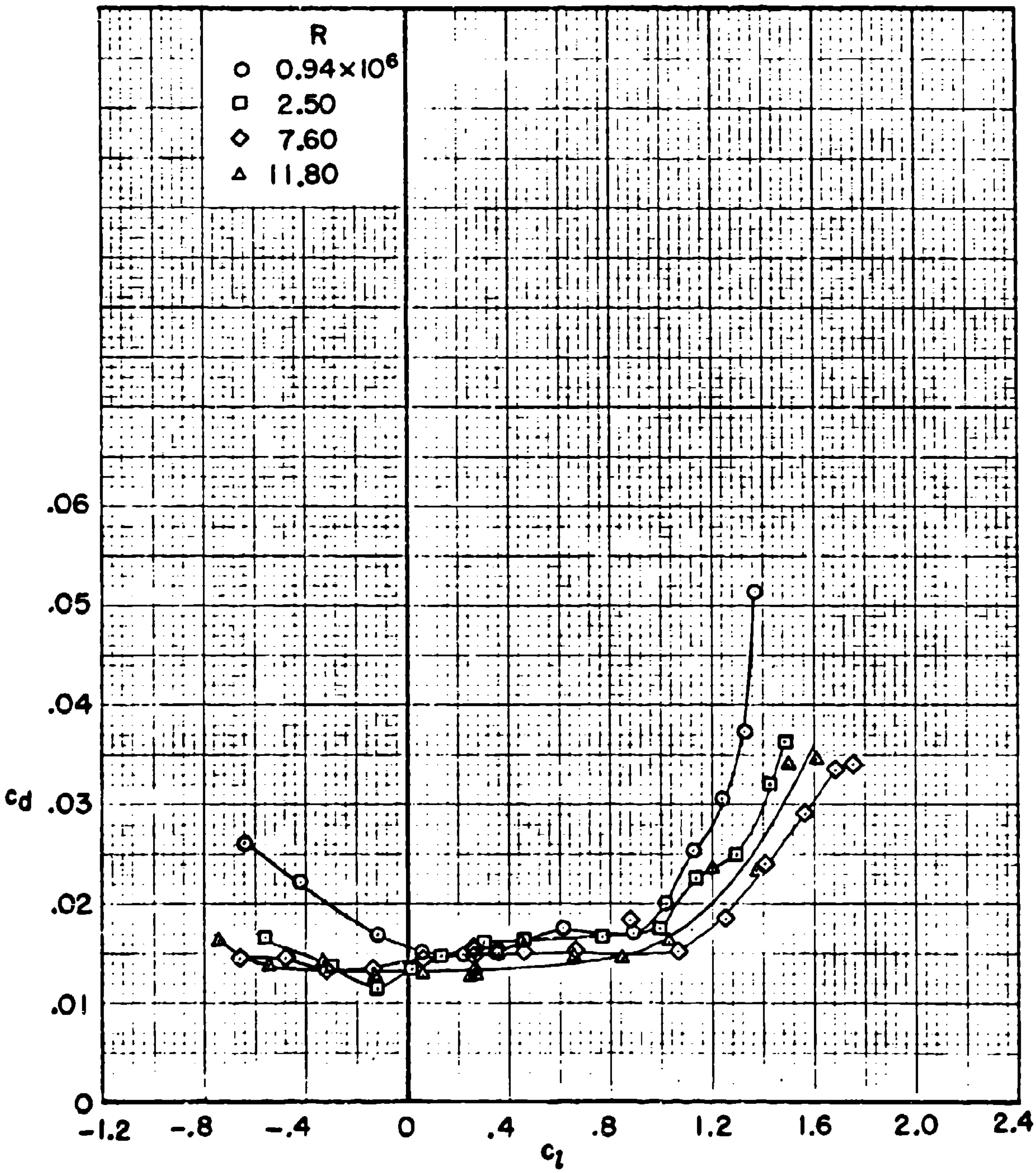
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF A 12-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. R = 2.56 x 10^6; MODEL SMOOTH



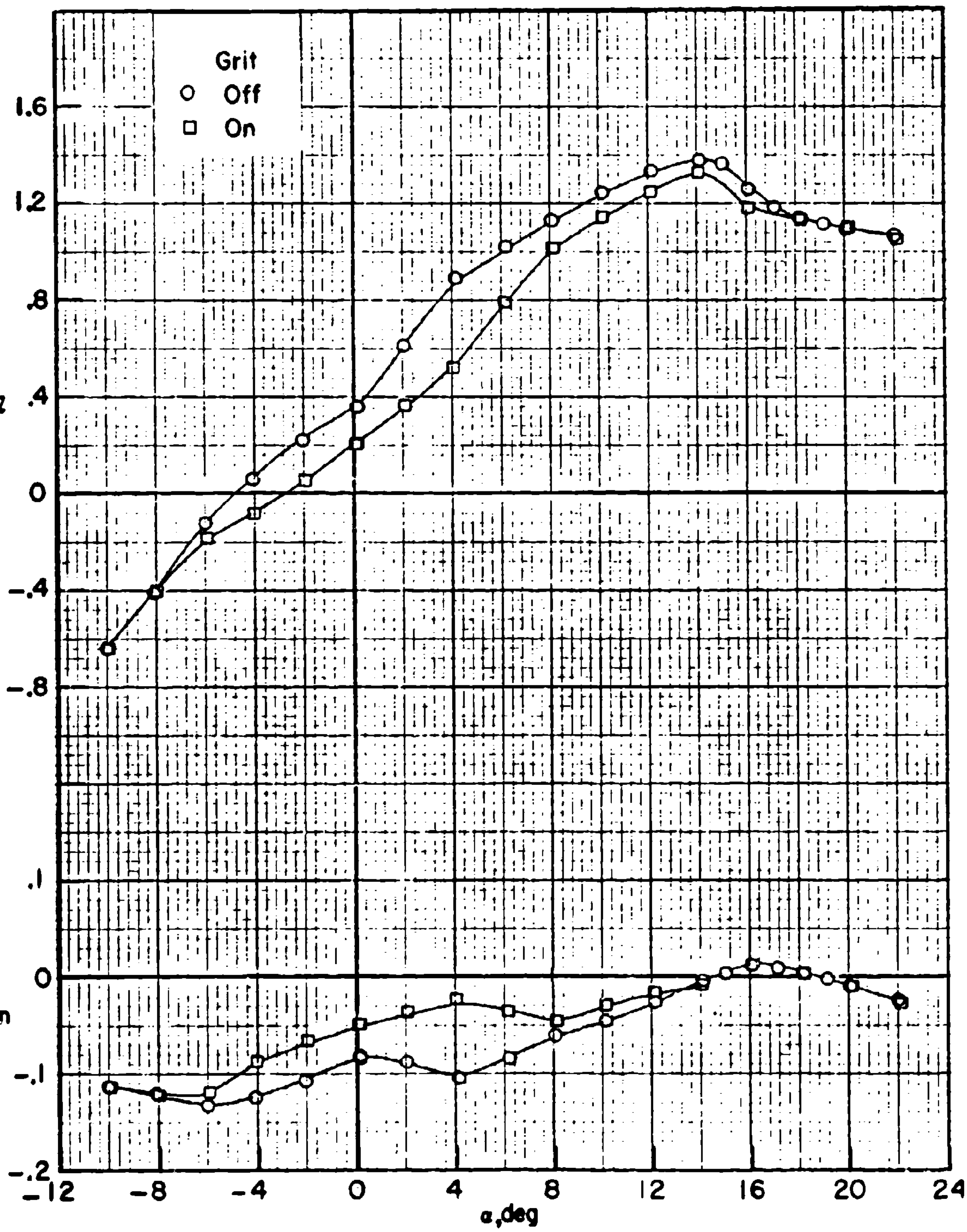
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; MODEL SMOOTH



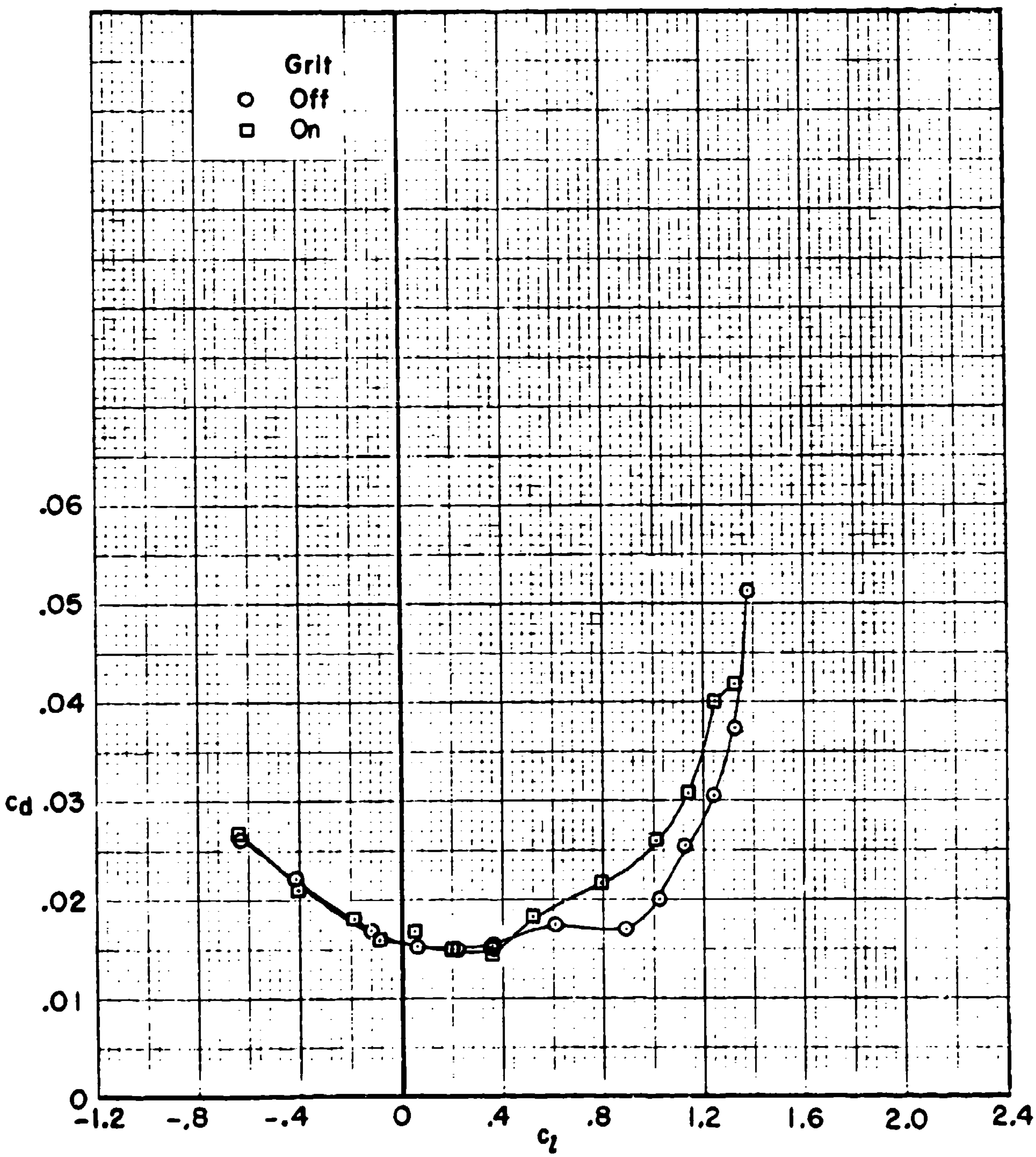
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; MODEL SMOOTH



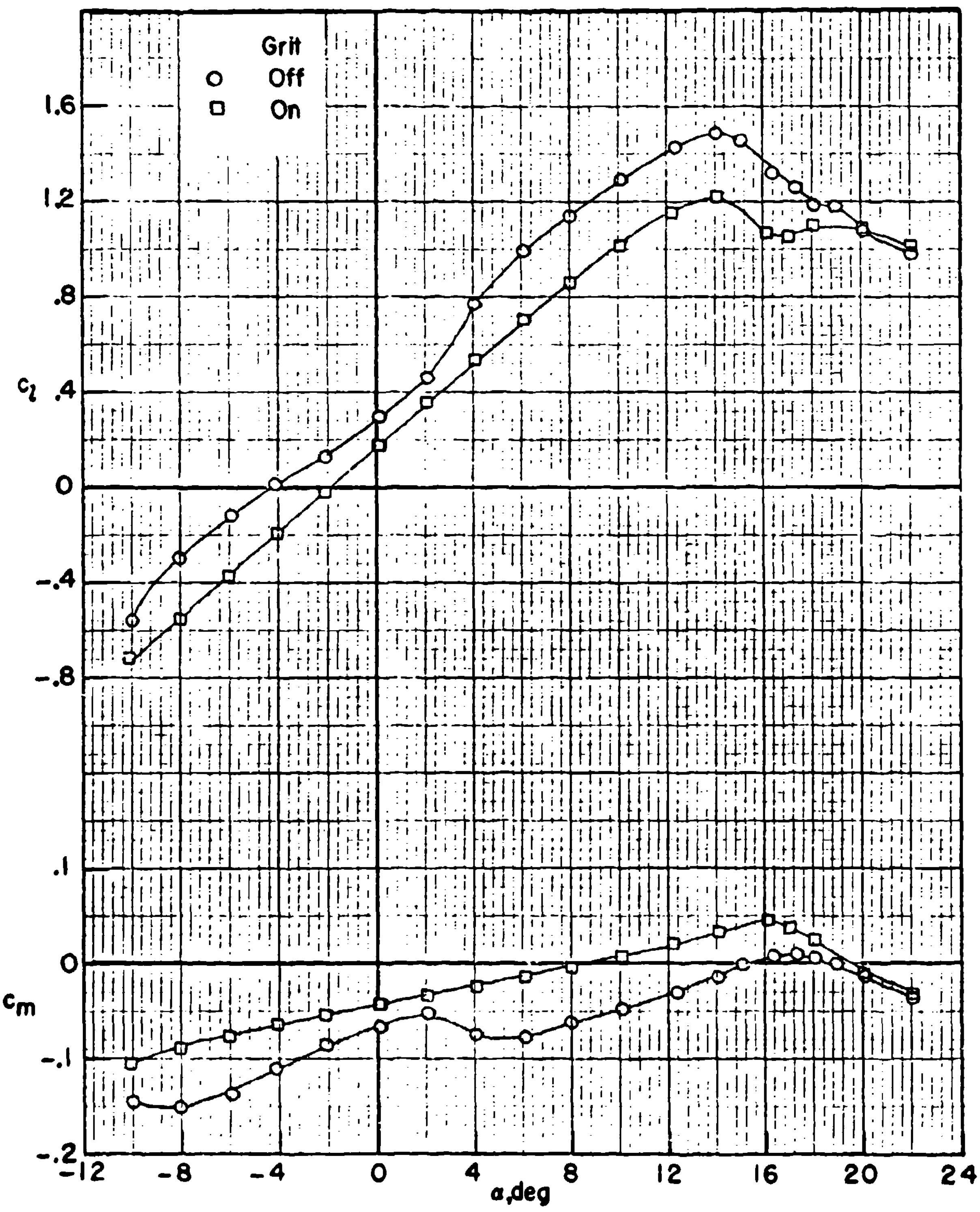
TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 0.94 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 0.94 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 2.5 x 10^6



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. M = 0.26; R = 2.5 x 10^6

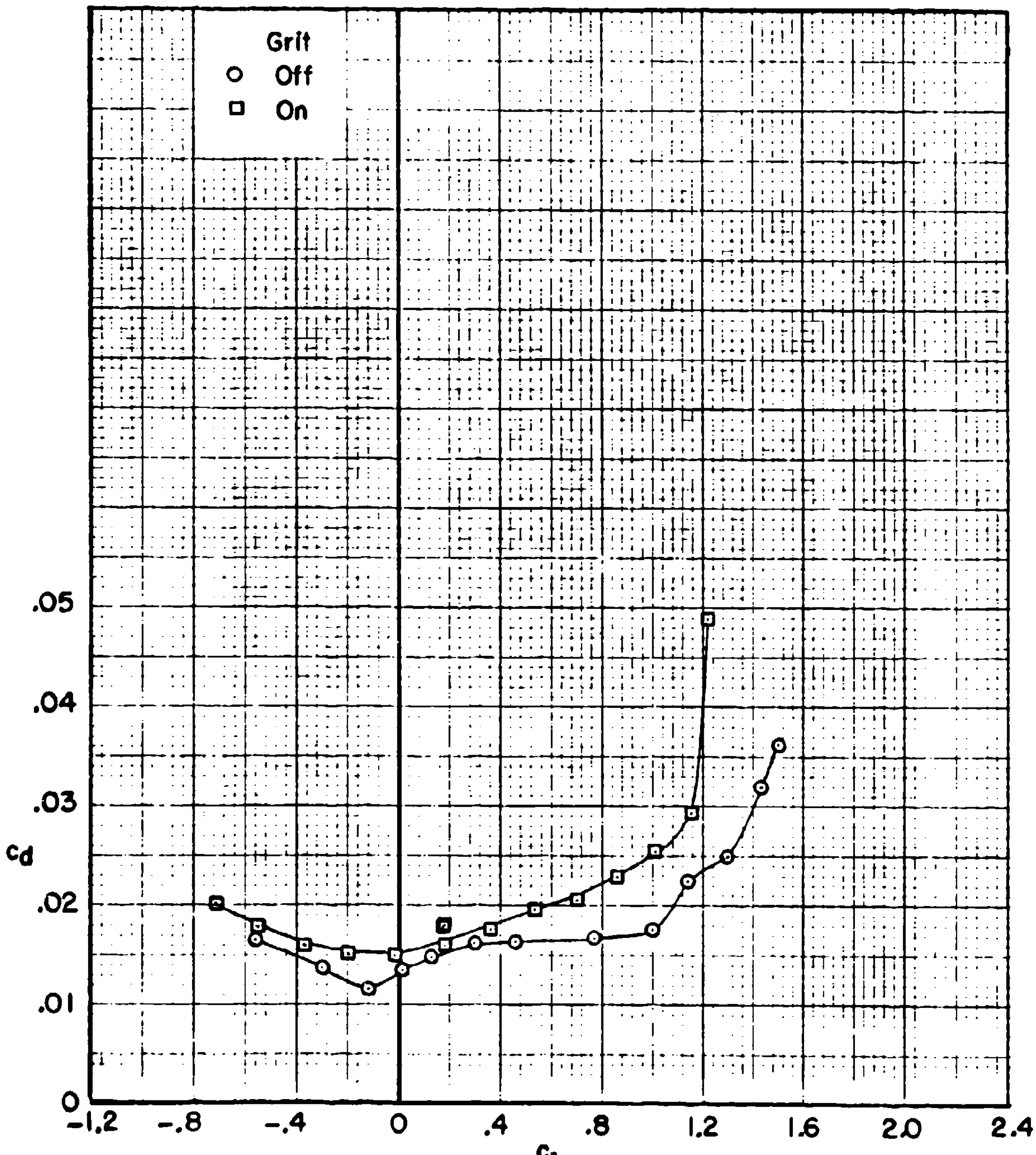


Figure C.23A

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. R = 2.50 x 10^6; MODEL SMOOTH

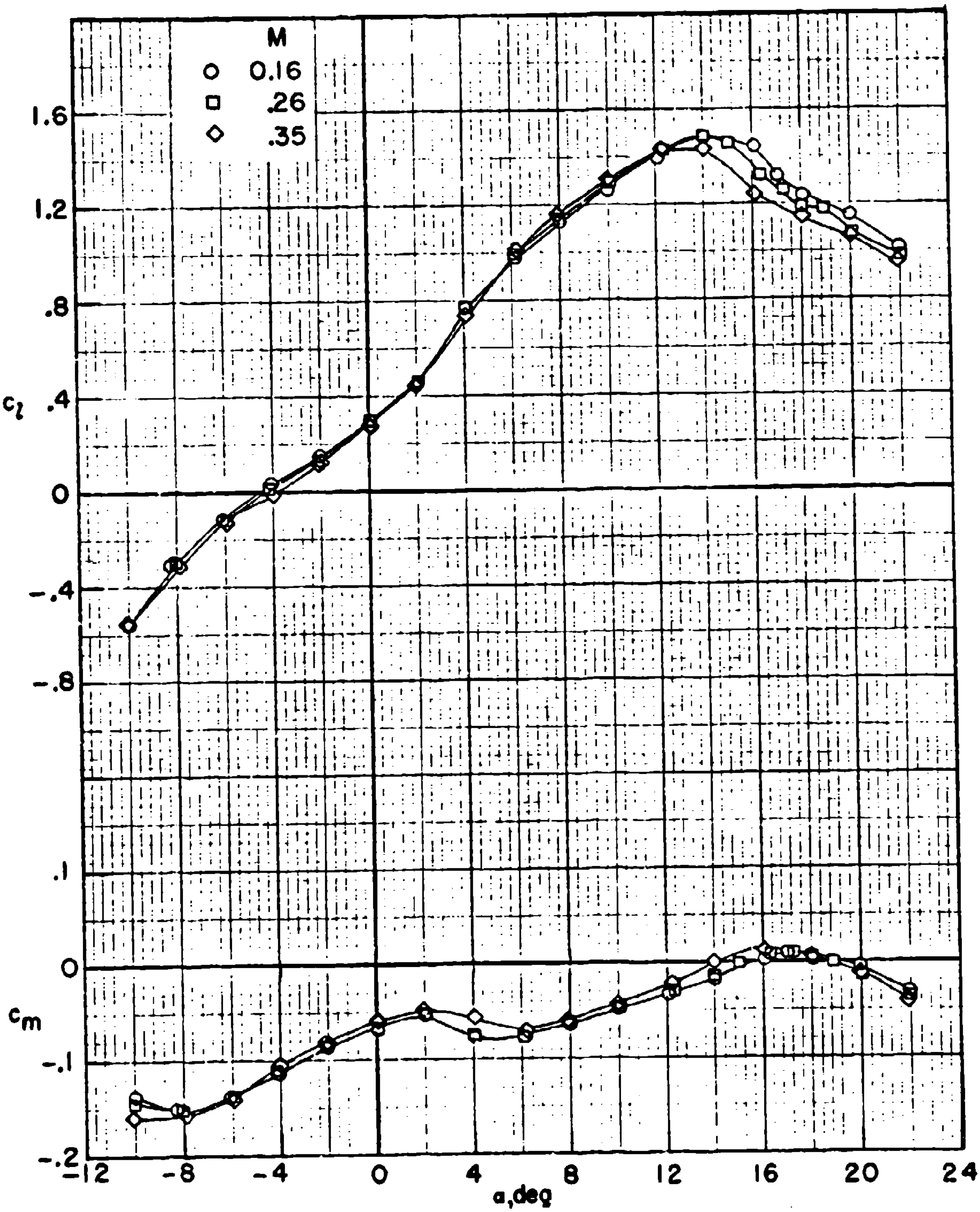
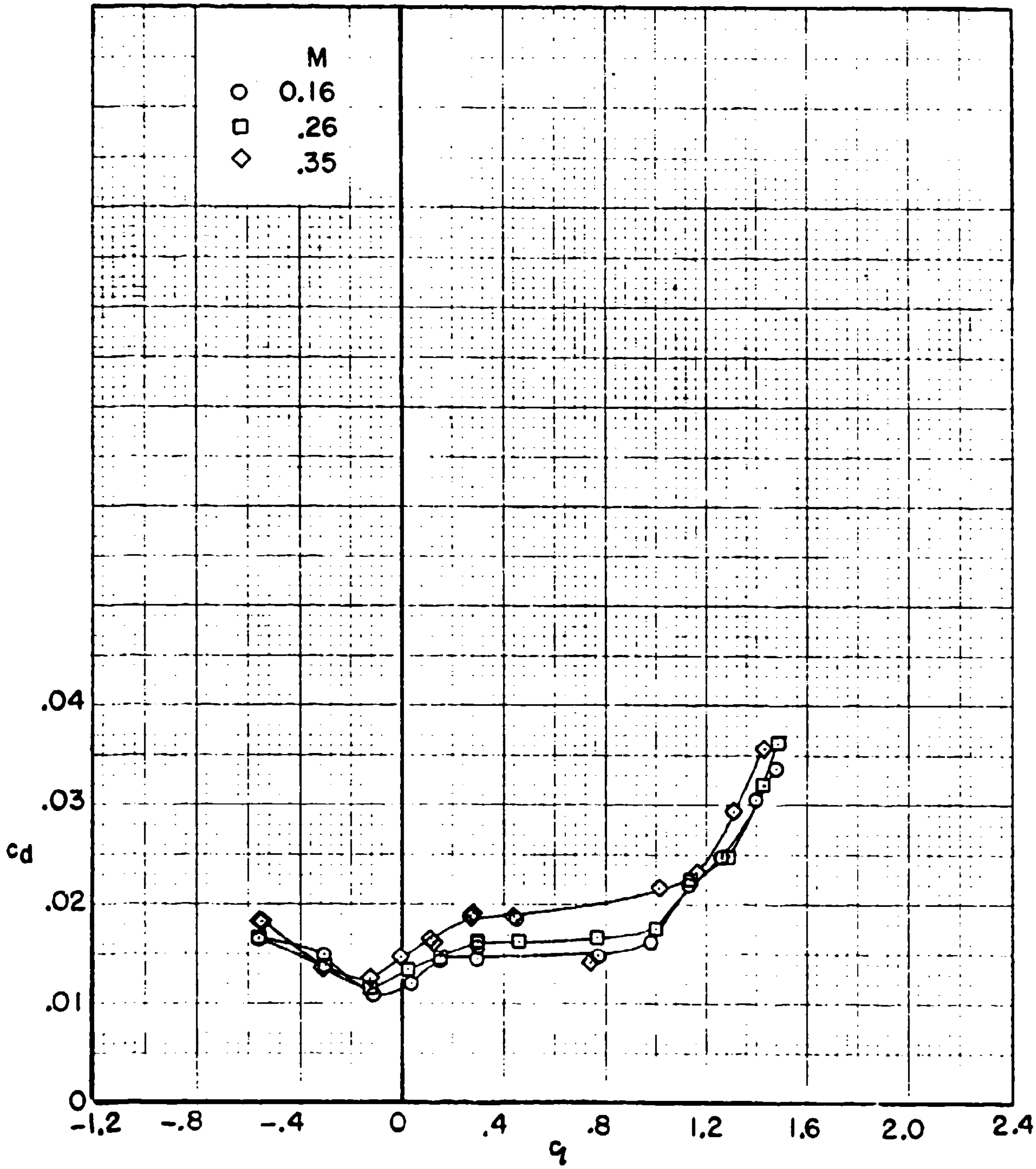


Figure C.23B

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH LEADING EDGE FORWARD. R = 2.50 x 10^6; MODEL SMOOTH



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; MODEL SMOOTH

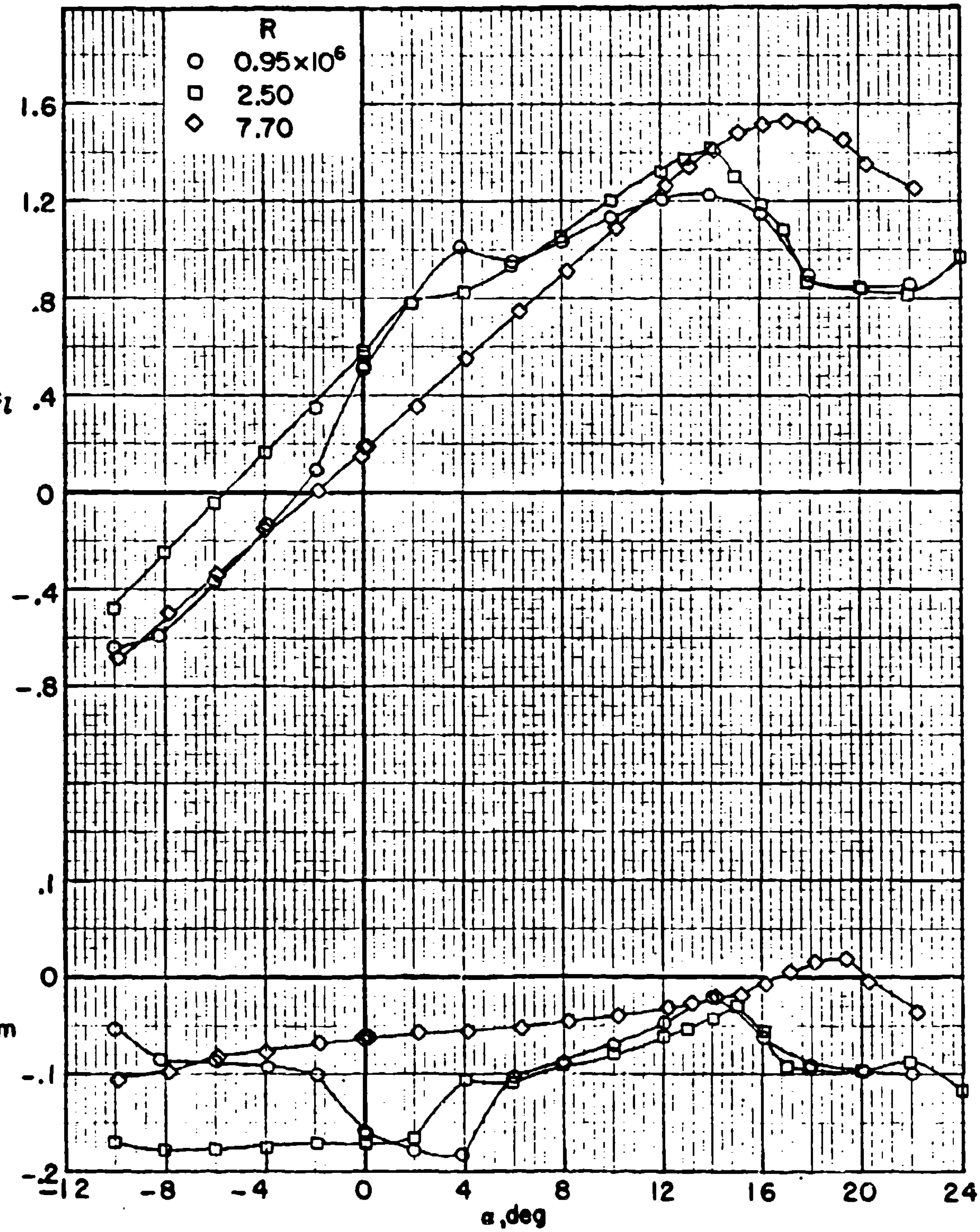


Figure C.24B

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; MODEL SMOOTH

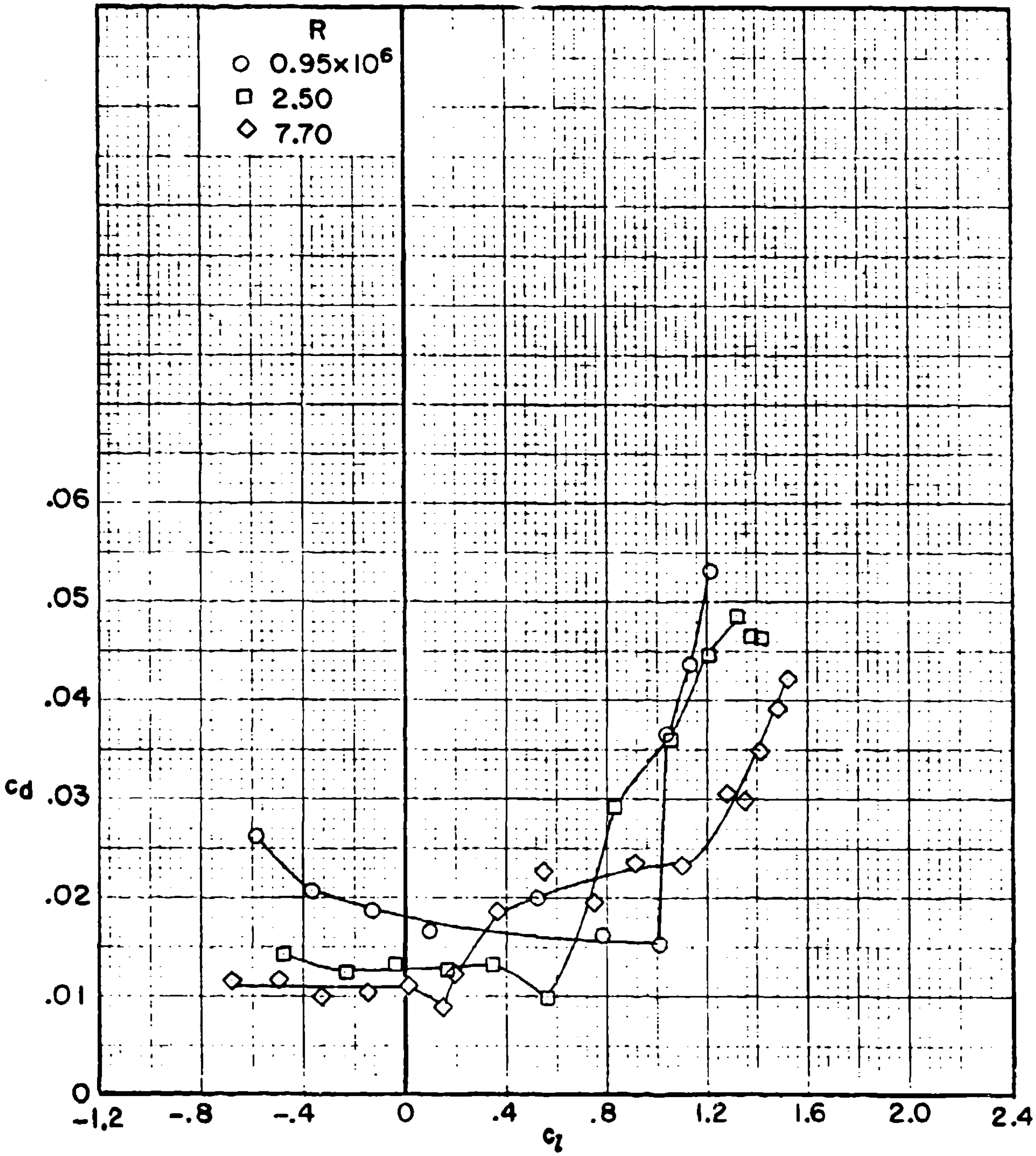


Figure C.25A

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 0.95 x 10^6

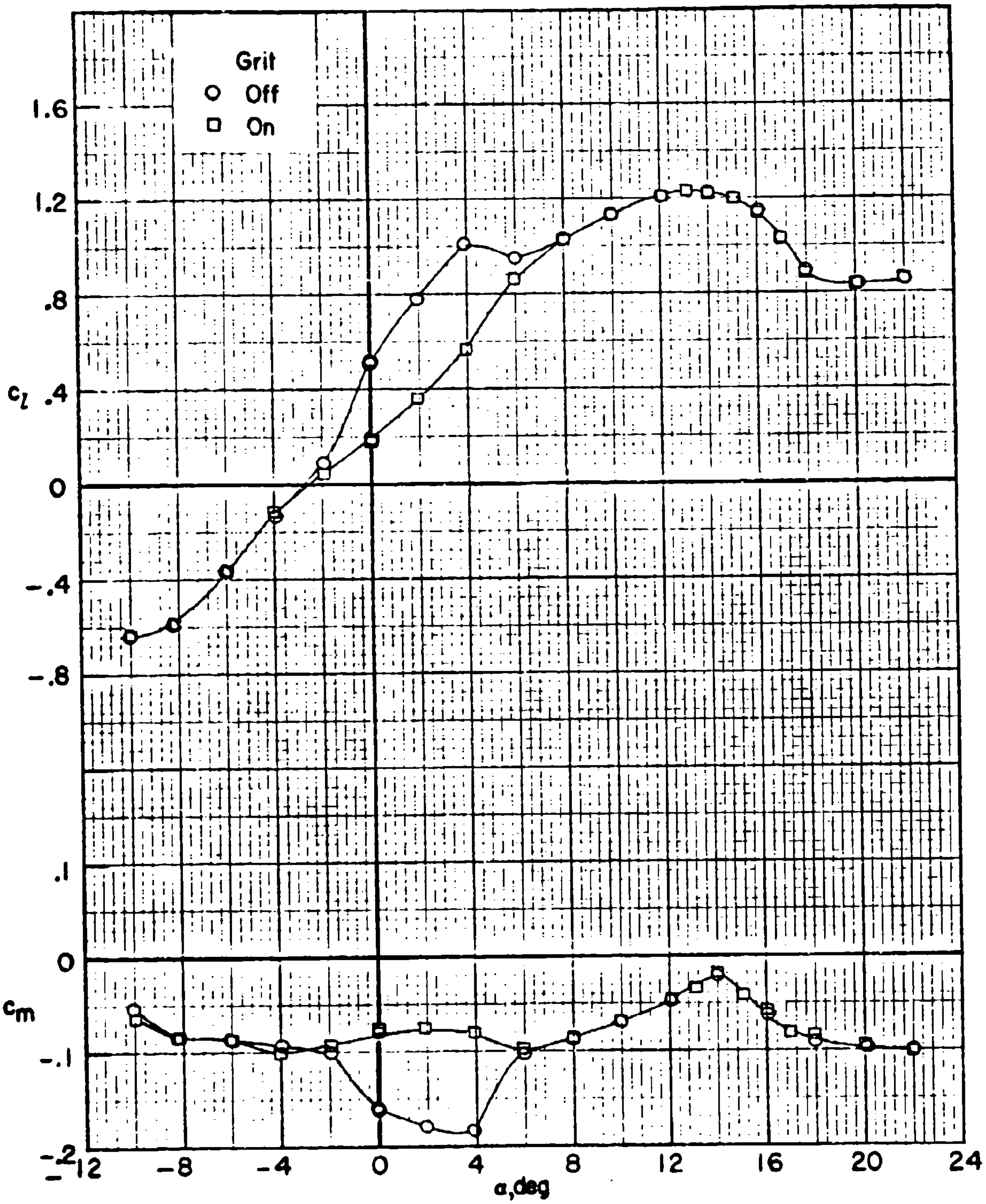
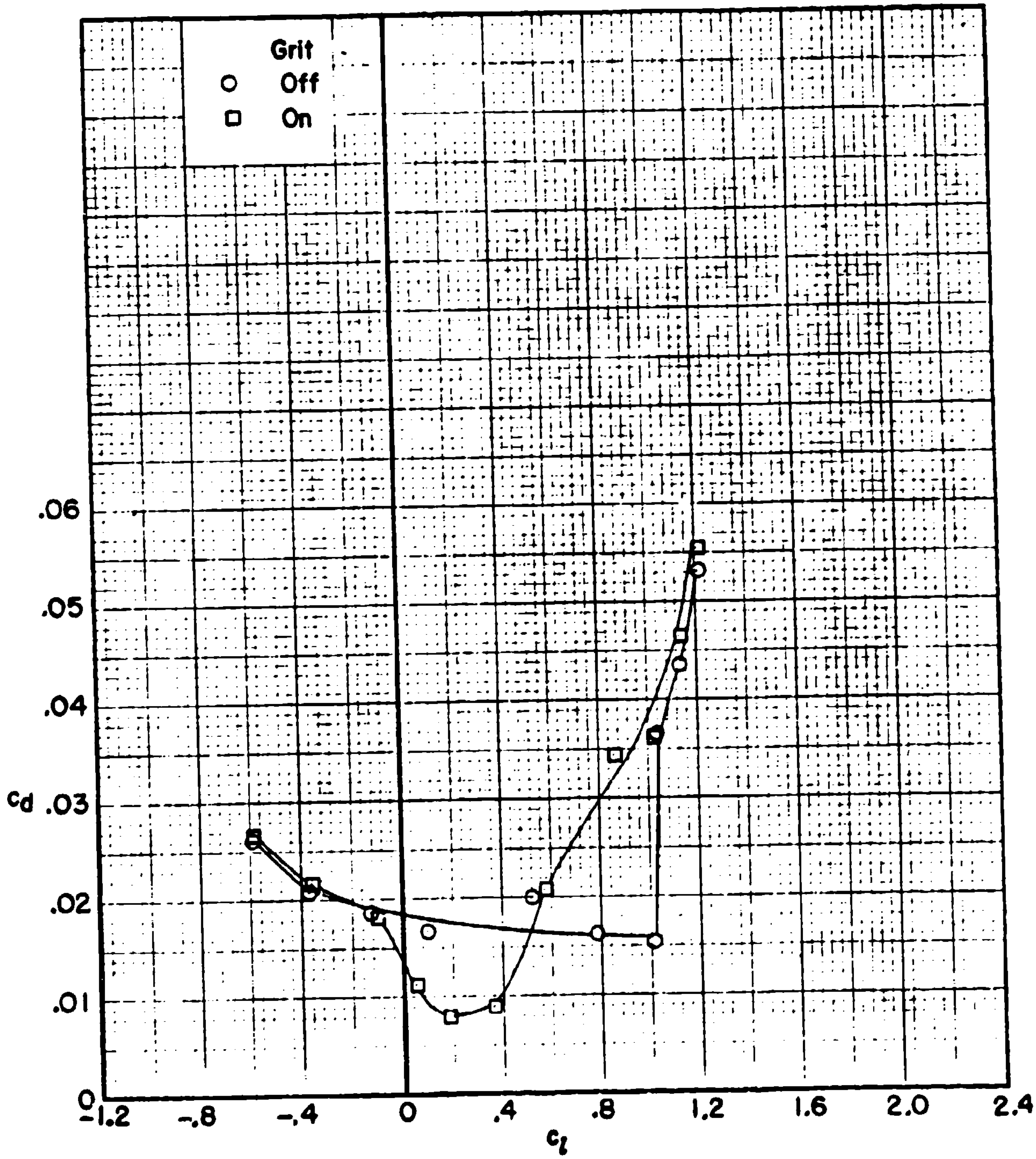


Figure C.25B

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. $M = 0.26$; $R = 0.95 \times 10^6$



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 2.50 x 10[6]

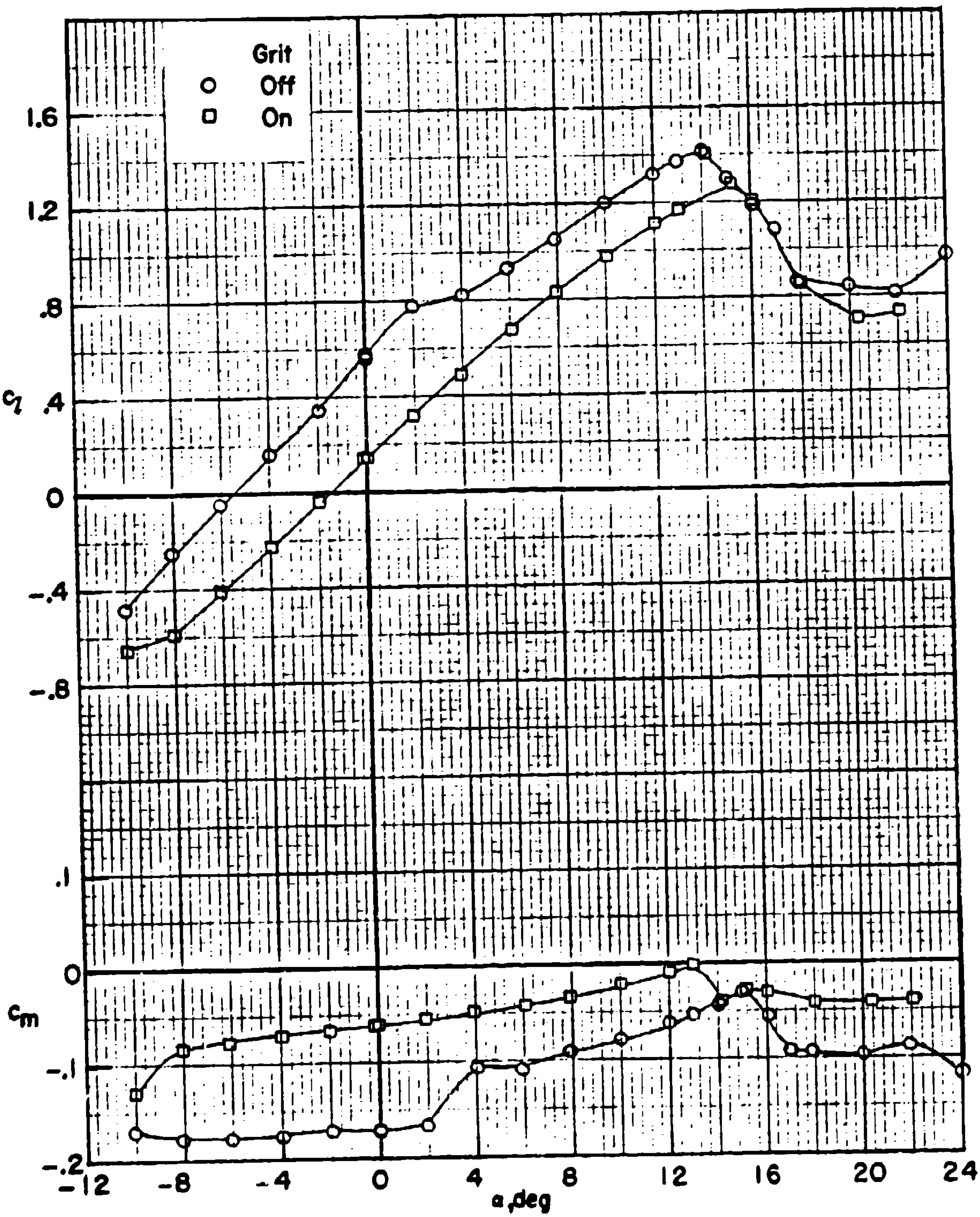


Figure C.26B

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. M = 0.26; R = 2.50 x 106

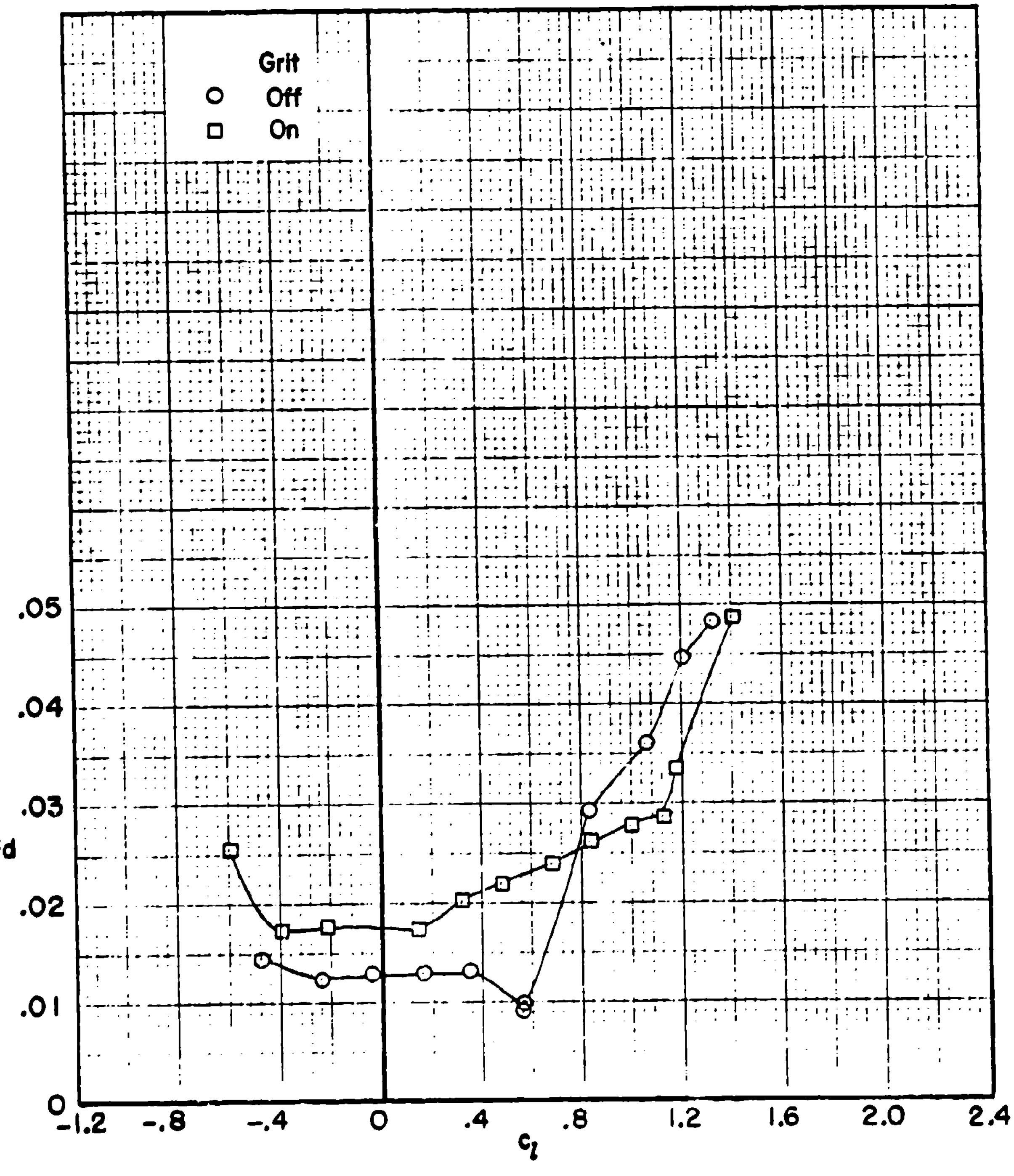


Figure C.27A

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. $M = 0.26$; $R = 7.70 \times 10^6$

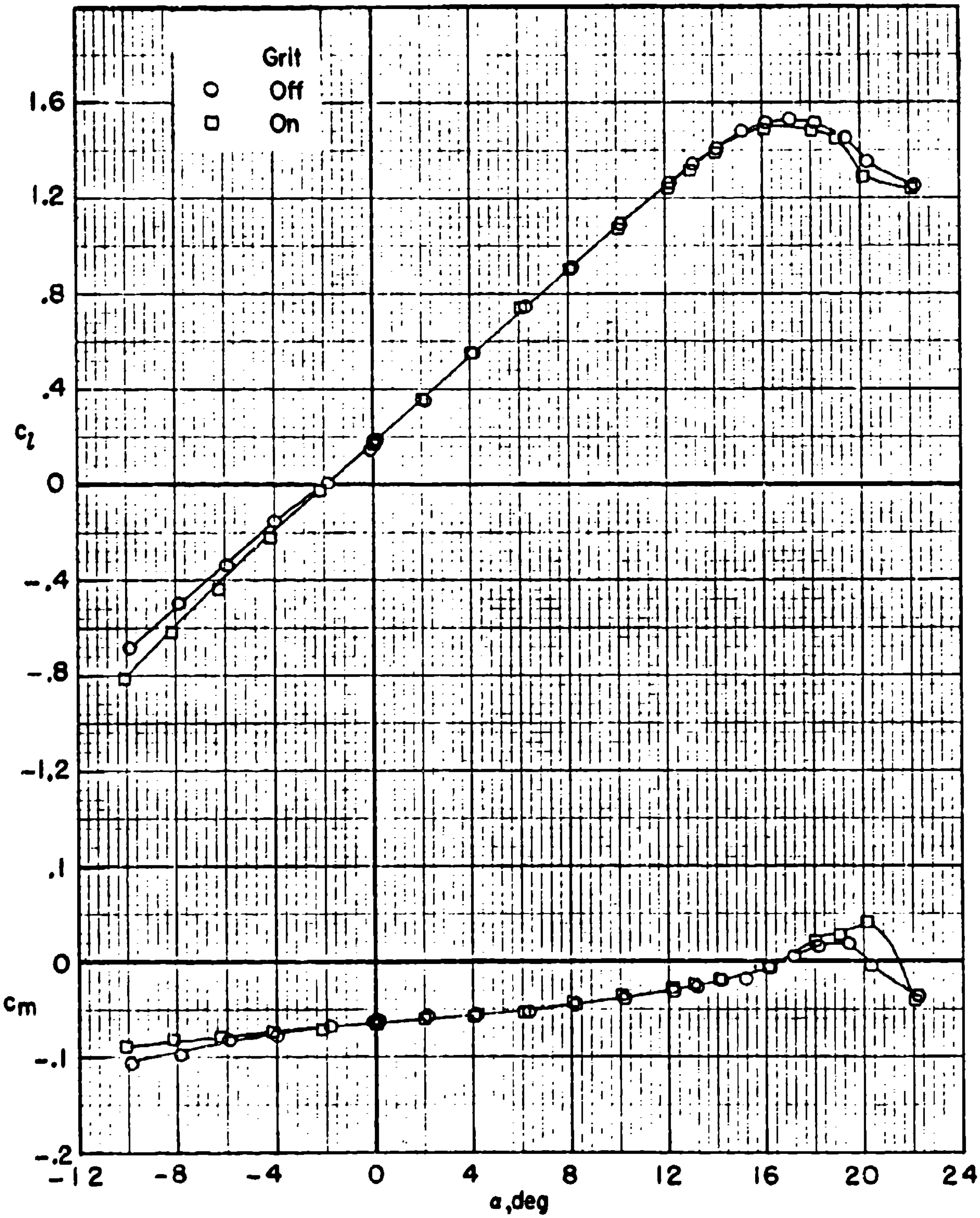


Figure C.27B

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. $M = 0.26$; $R = 7.70 \times 10^6$

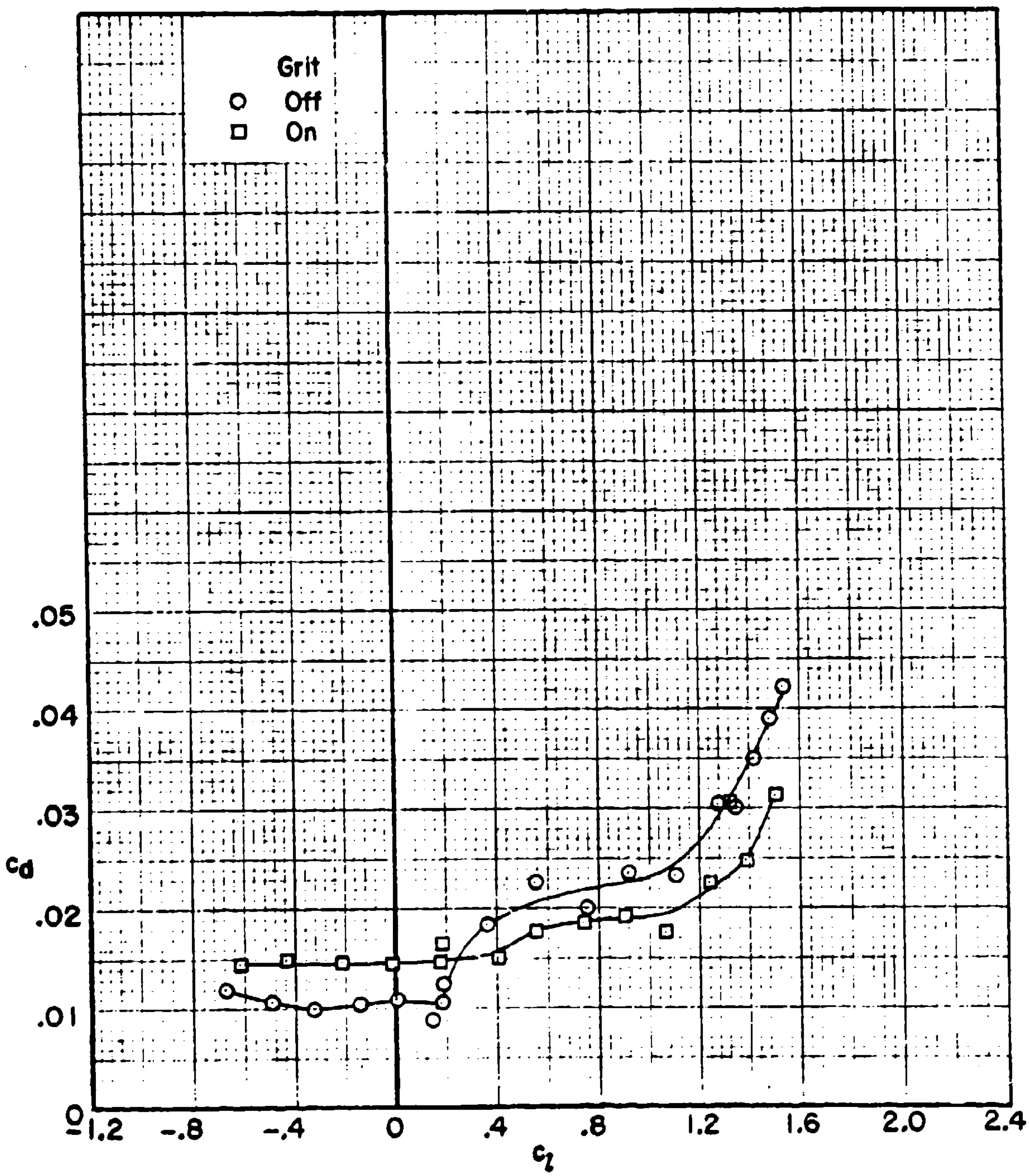
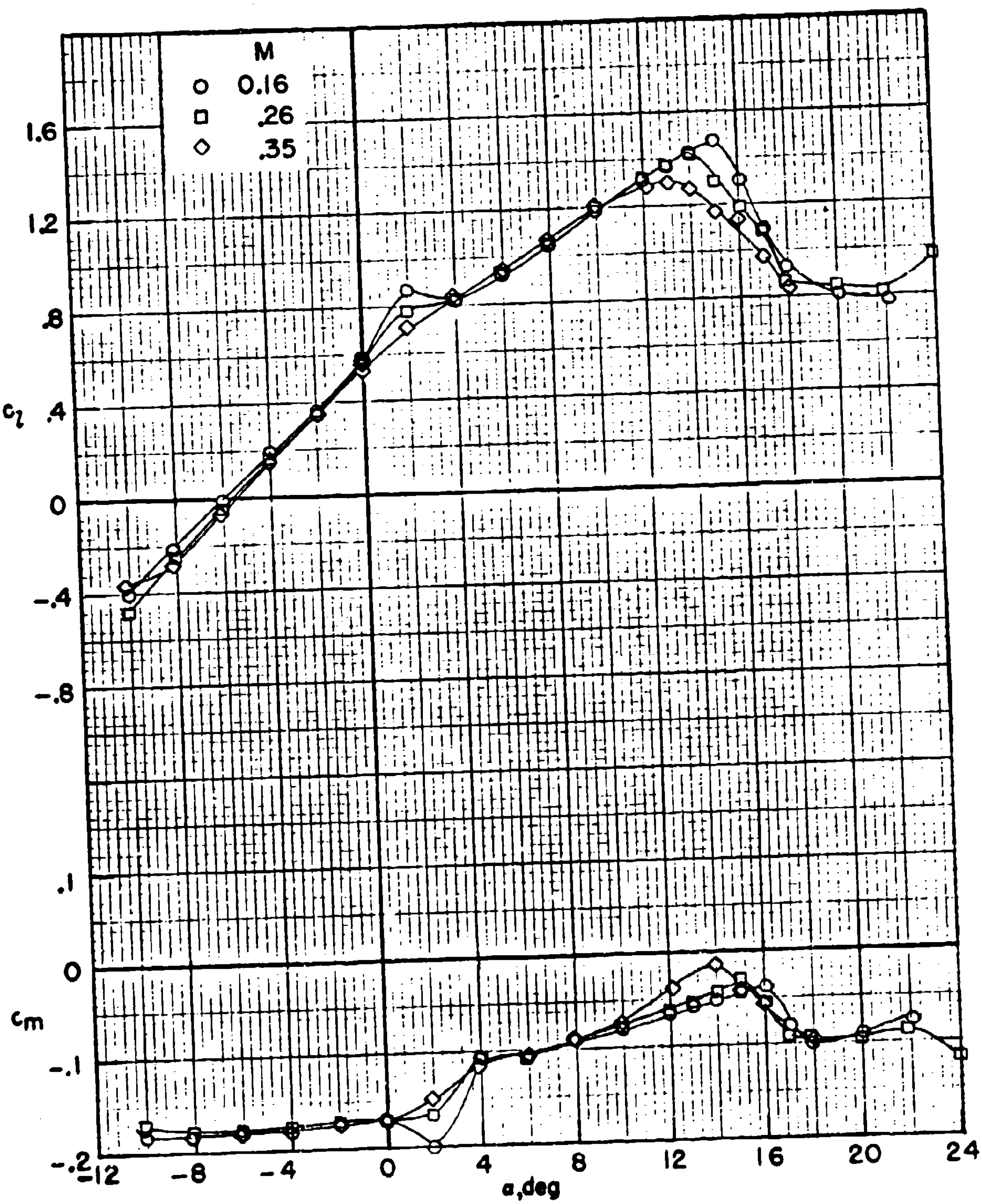
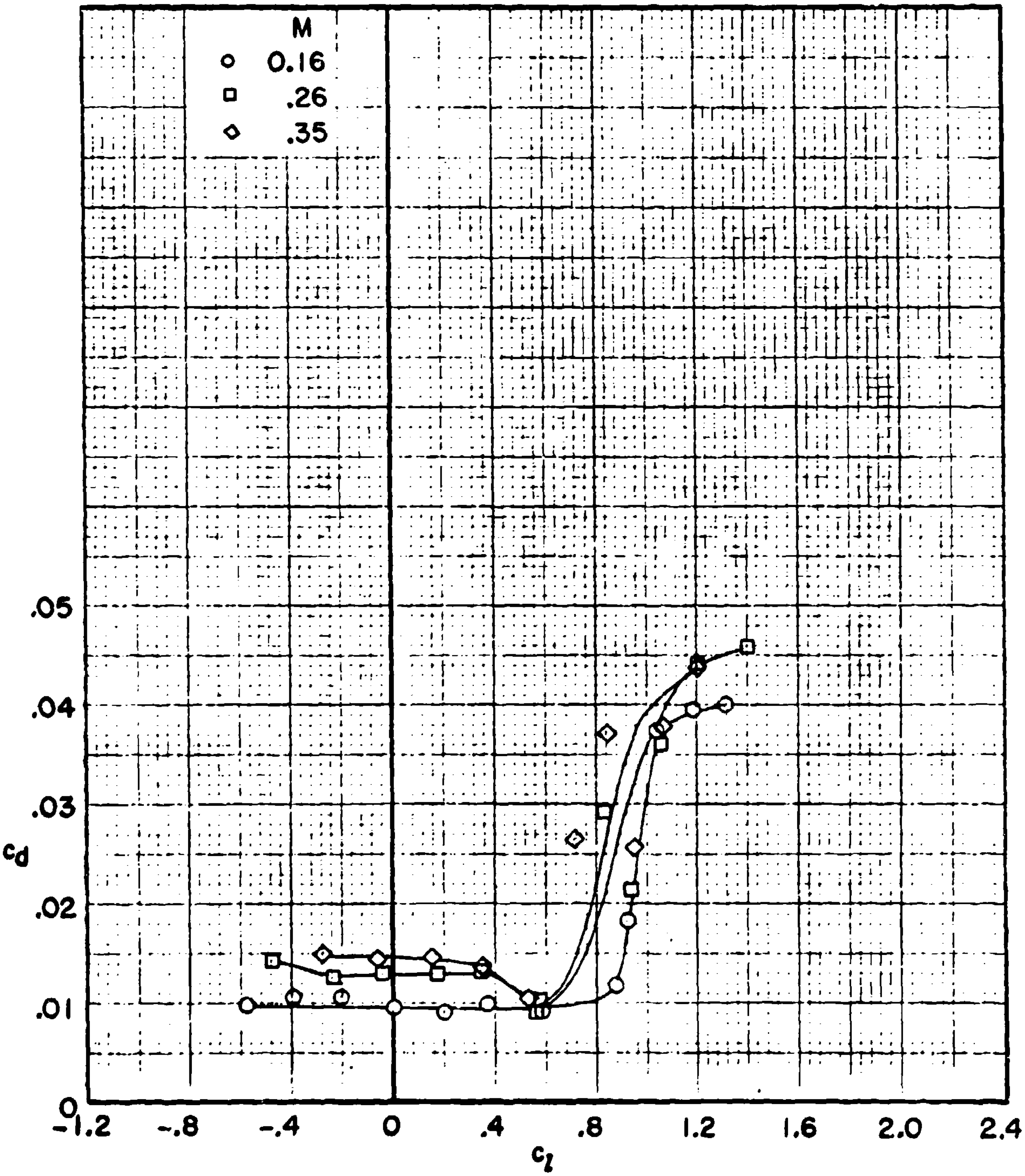


Figure C.28A

TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. R = 2.50 x 10^6; MODEL SMOOTH



TWO-DIMENSIONAL SECTION CHARACTERISTICS OF AN 18-PERCENT RVR AIRFOIL WITH TRAILING EDGE FORWARD. R = 2.50 x 10^6; MODEL SMOOTH



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APPENDIX D

AIRFOIL SECTION DATA

This appendix contains the two sets of airfoil section lift and drag data developed as described in Section 5.1 from the results of the Langley Low Turbulence Pressure Tunnel tests. The first set (Figs D1 through D18) is developed for the Reynolds number range used in the model rotor tests, and the second set (Figs D19 through D36) corresponds to the Reynolds number range of a full scale rotor.

Figure D.1

SECTION LIFT COEFFICIENT - 6% AIRFOIL, FORWARD
MODEL REYNOLDS NUMBER

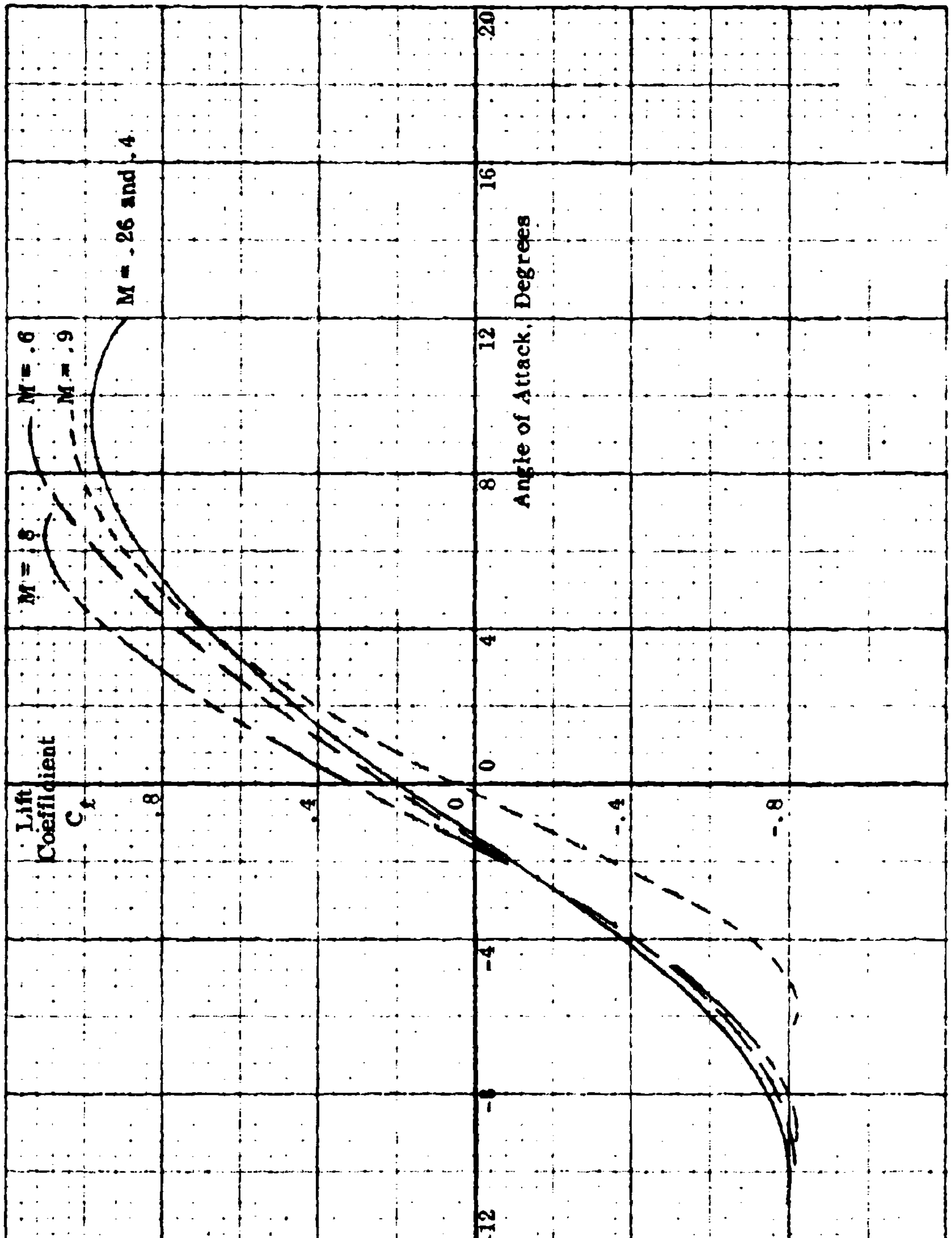
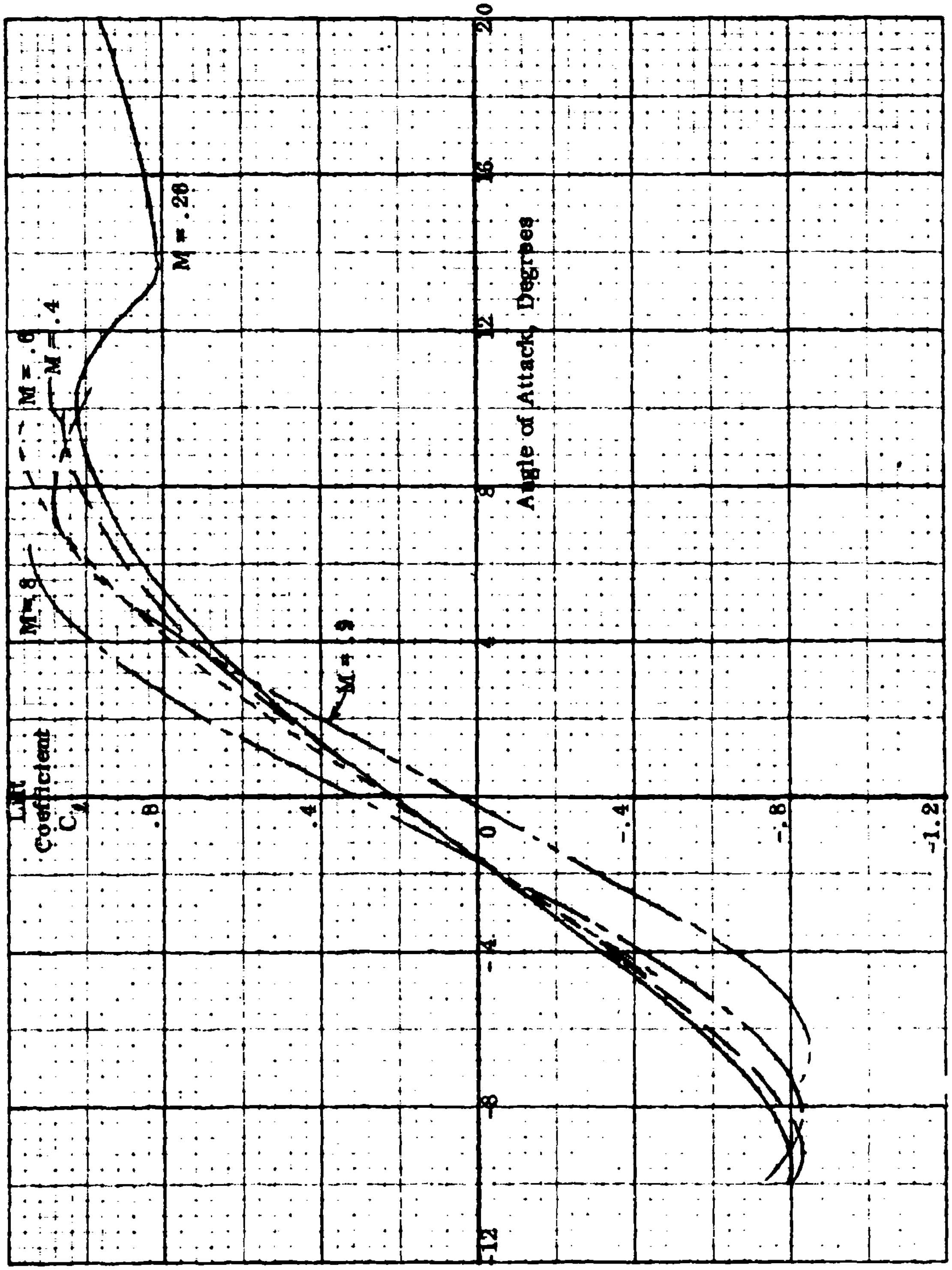
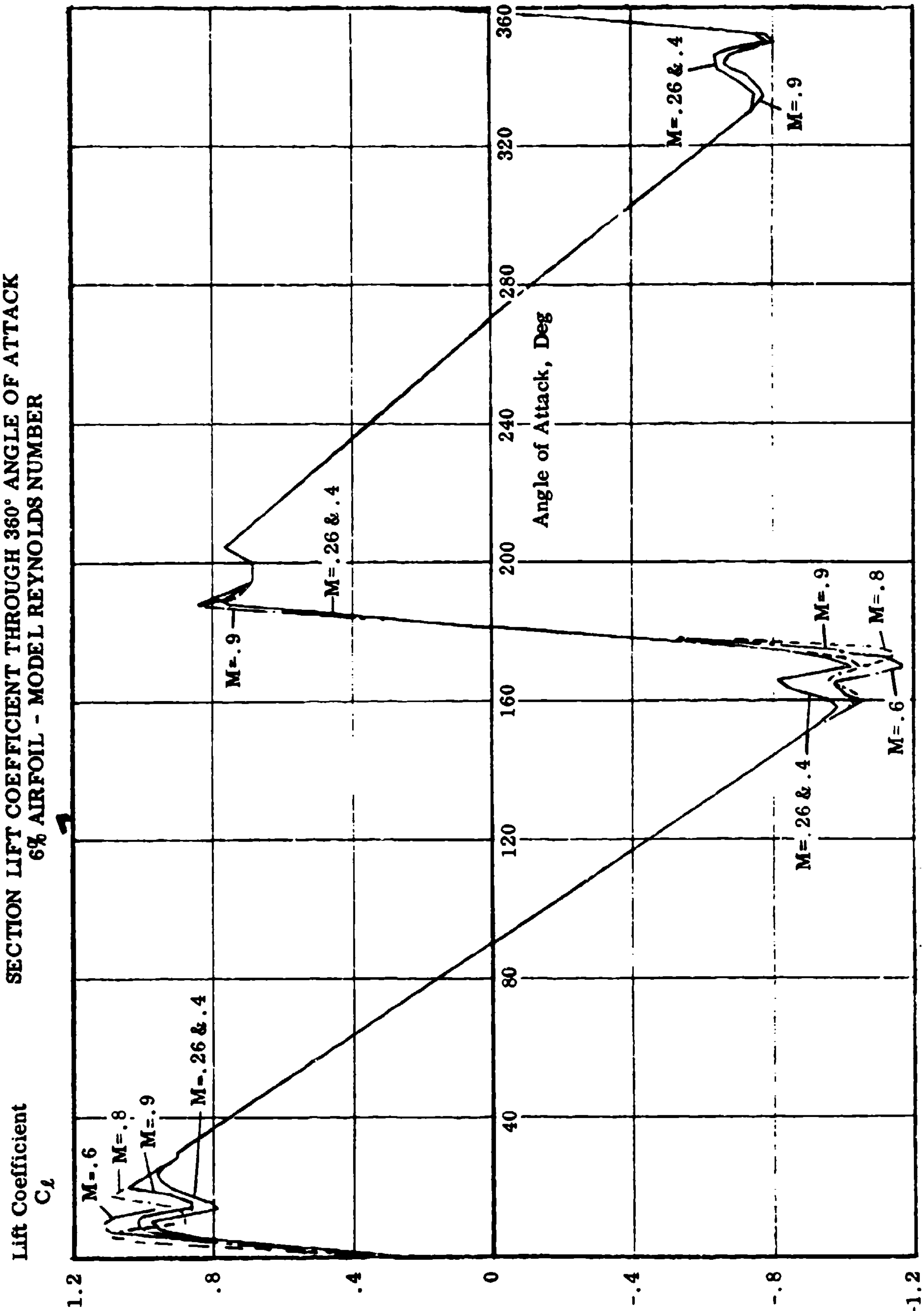


Figure D.2

SECTION LIFT COEFFICIENT -6% AIRFOIL, REVERSE MODEL REYNOLDS NUMBER



SECTION LIFT COEFFICIENT THROUGH 360° ANGLE OF ATTACK
6% AIRFOIL - MODEL REYNOLDS NUMBER



SECTION DRAG COEFFICIENT - 6% AIRFOIL, FORWARD
MODEL REYNOLDS NUMBER

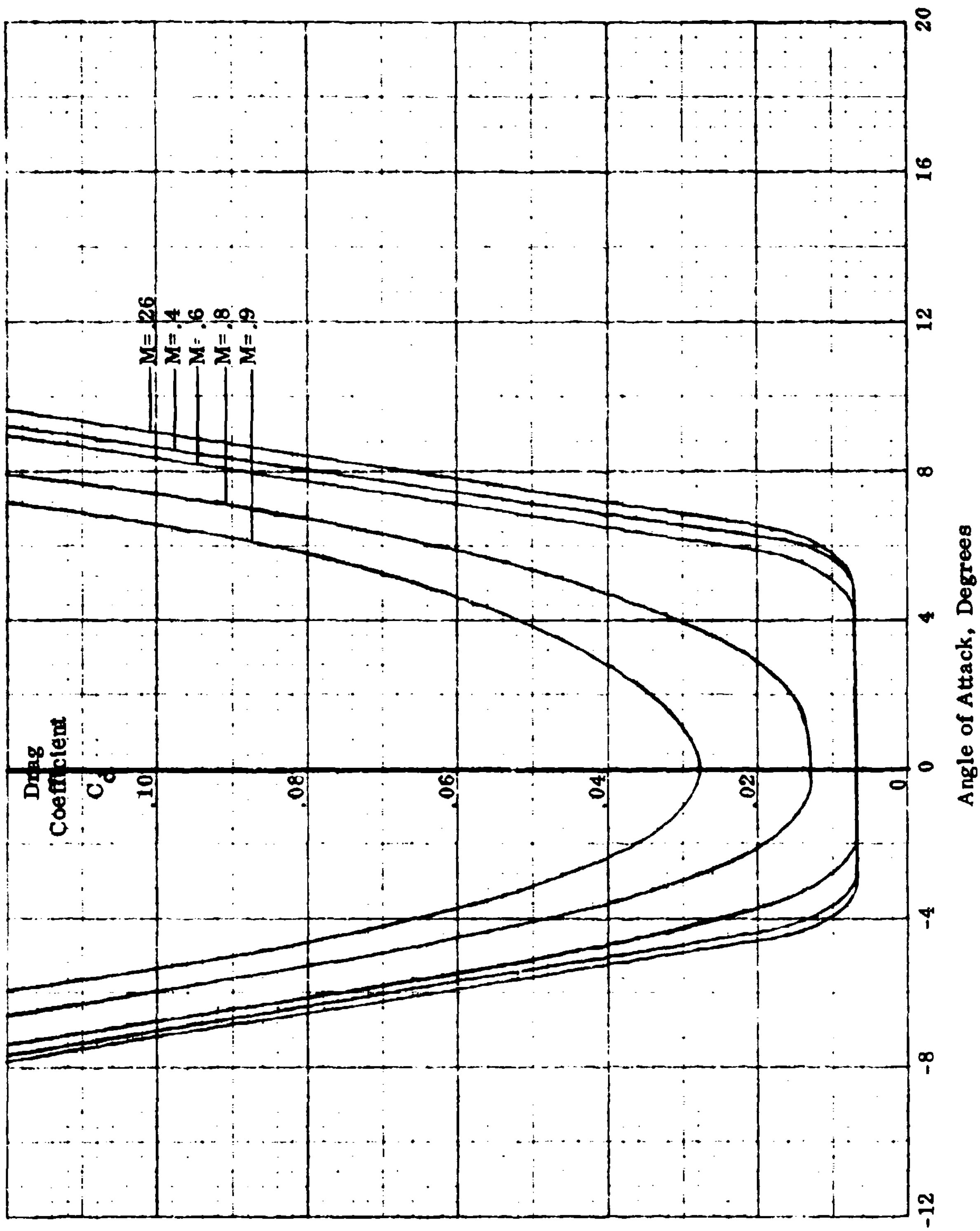


Figure D.5

SECTION DRAG COEFFICIENT - 6% AIRFOIL, REVERSE
MODEL REYNOLDS NUMBER

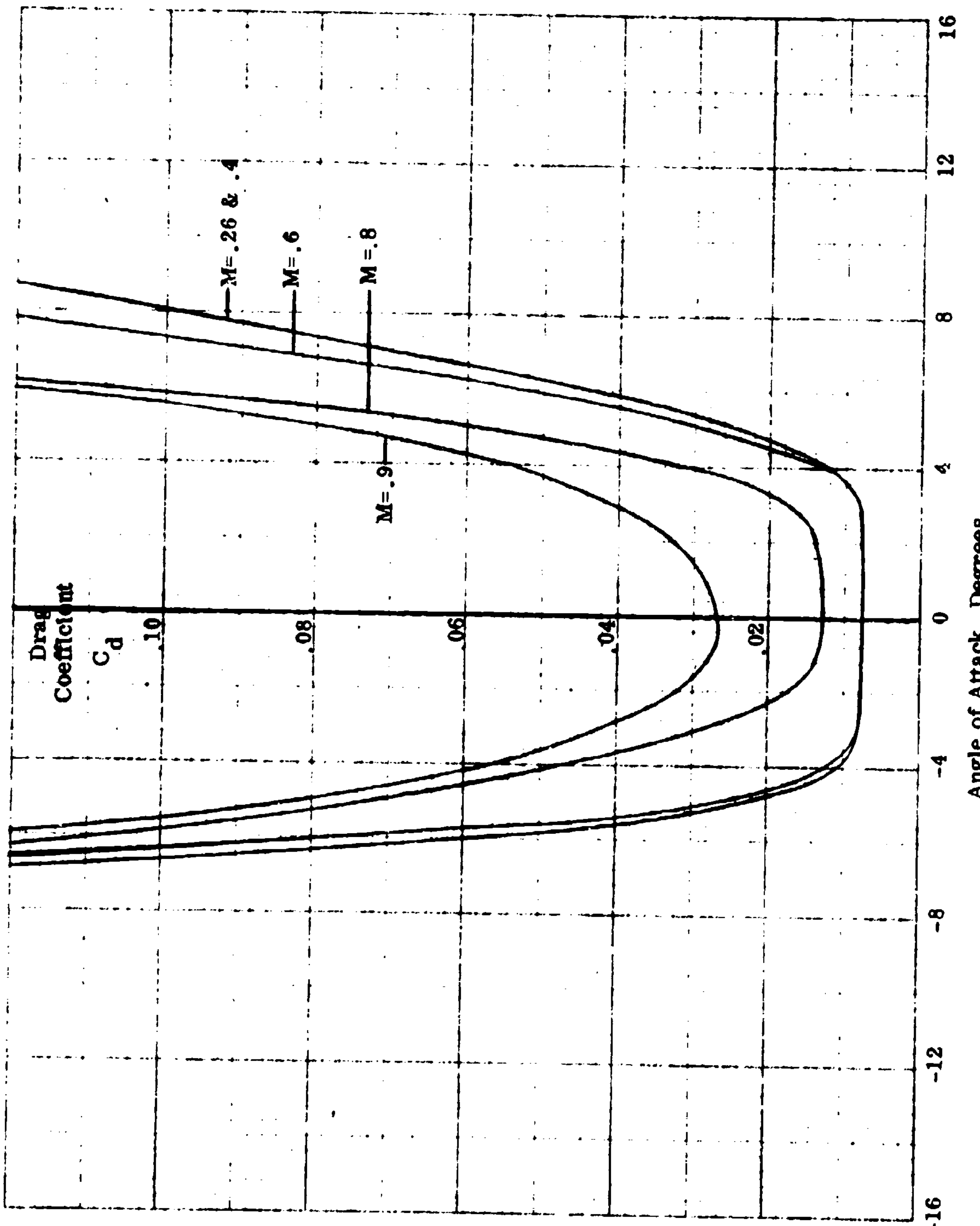


Figure D.6

SECTION DRAG COEFFICIENT THROUGH 360° ANGLE OF ATTACK
6% AIRFOIL - MODEL REYNOLDS NUMBER

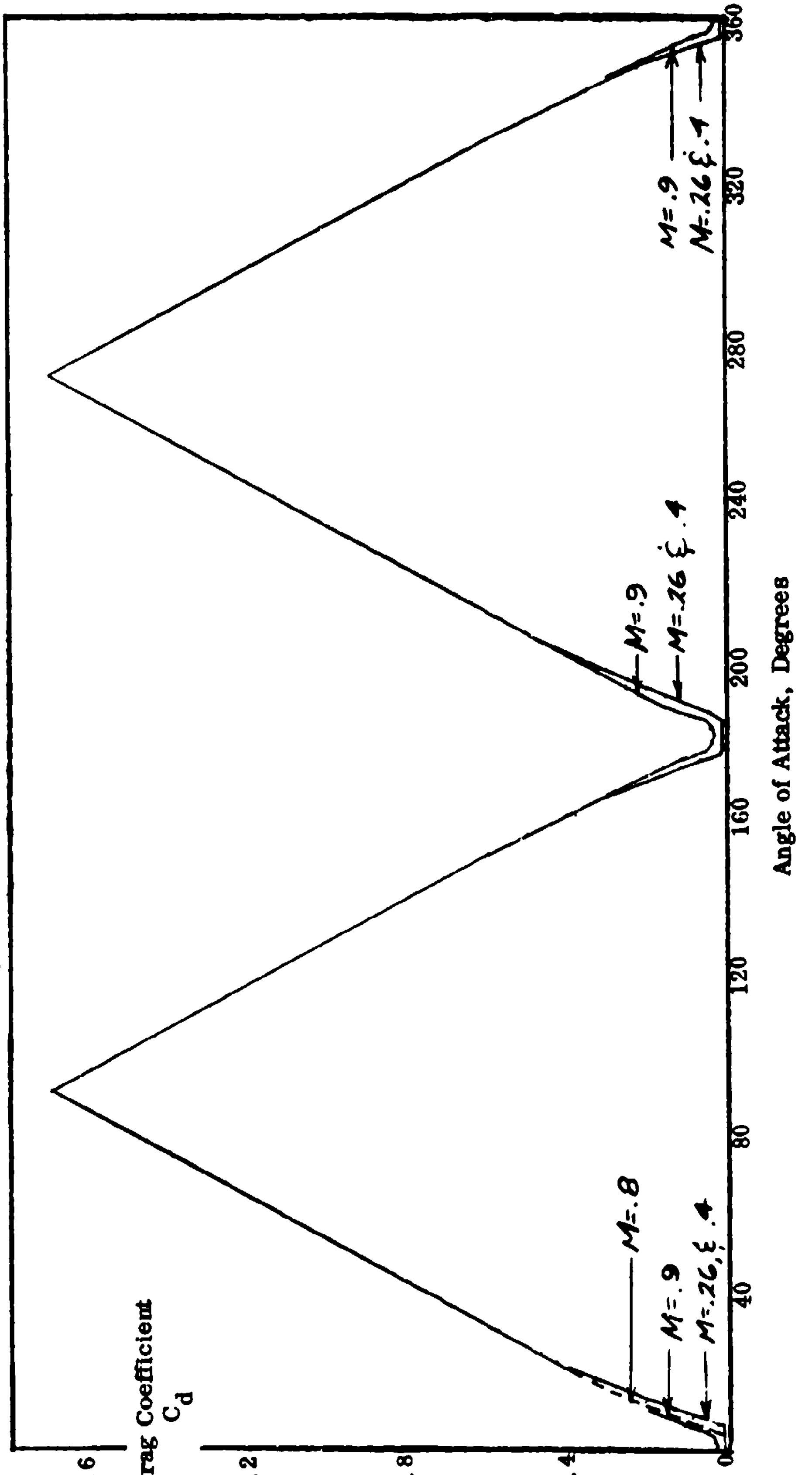


Figure D.7

SECTION LIFT COEFFICIENT - 12% AIRFOIL, FORWARD
MODEL REYNOLDS NUMBER

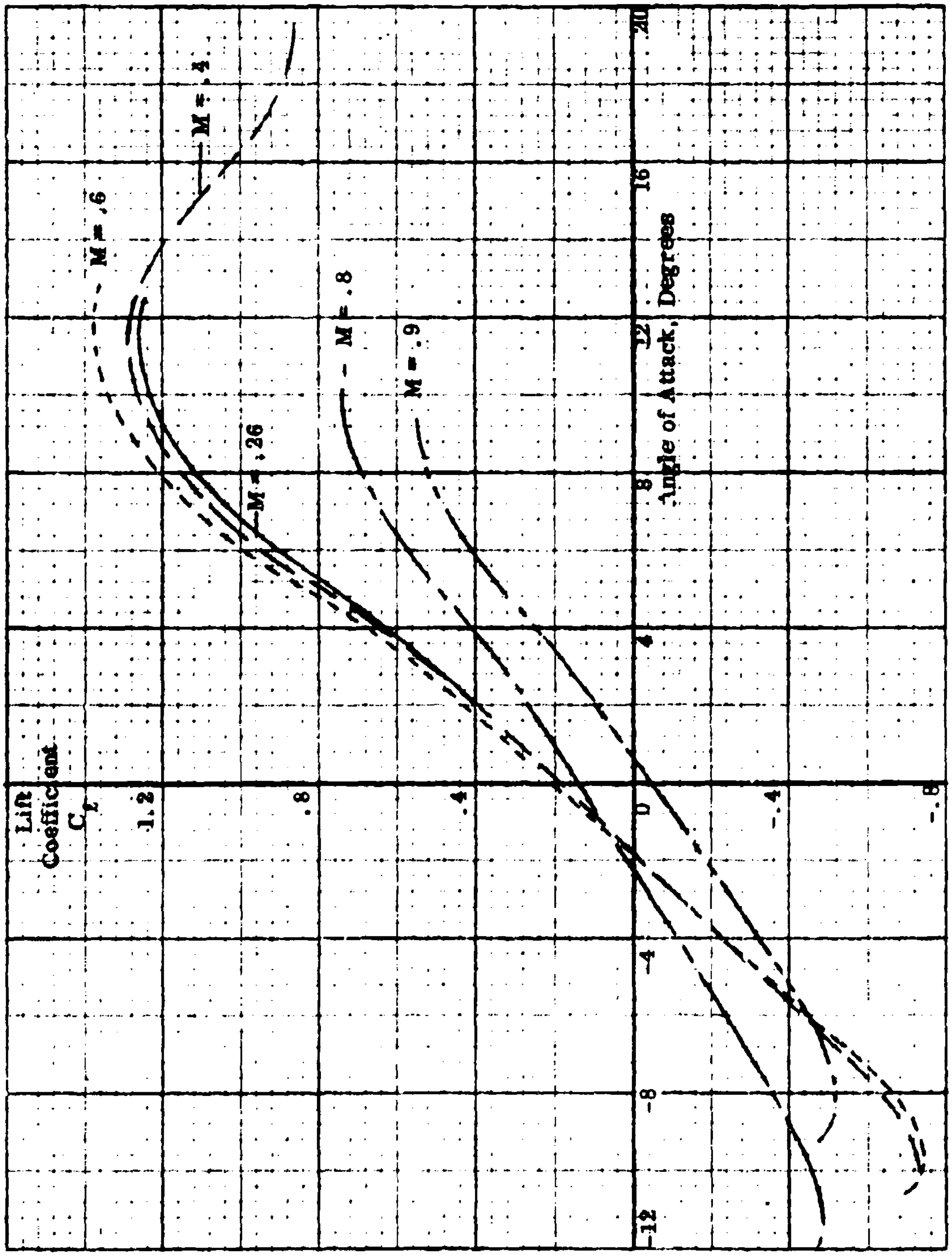
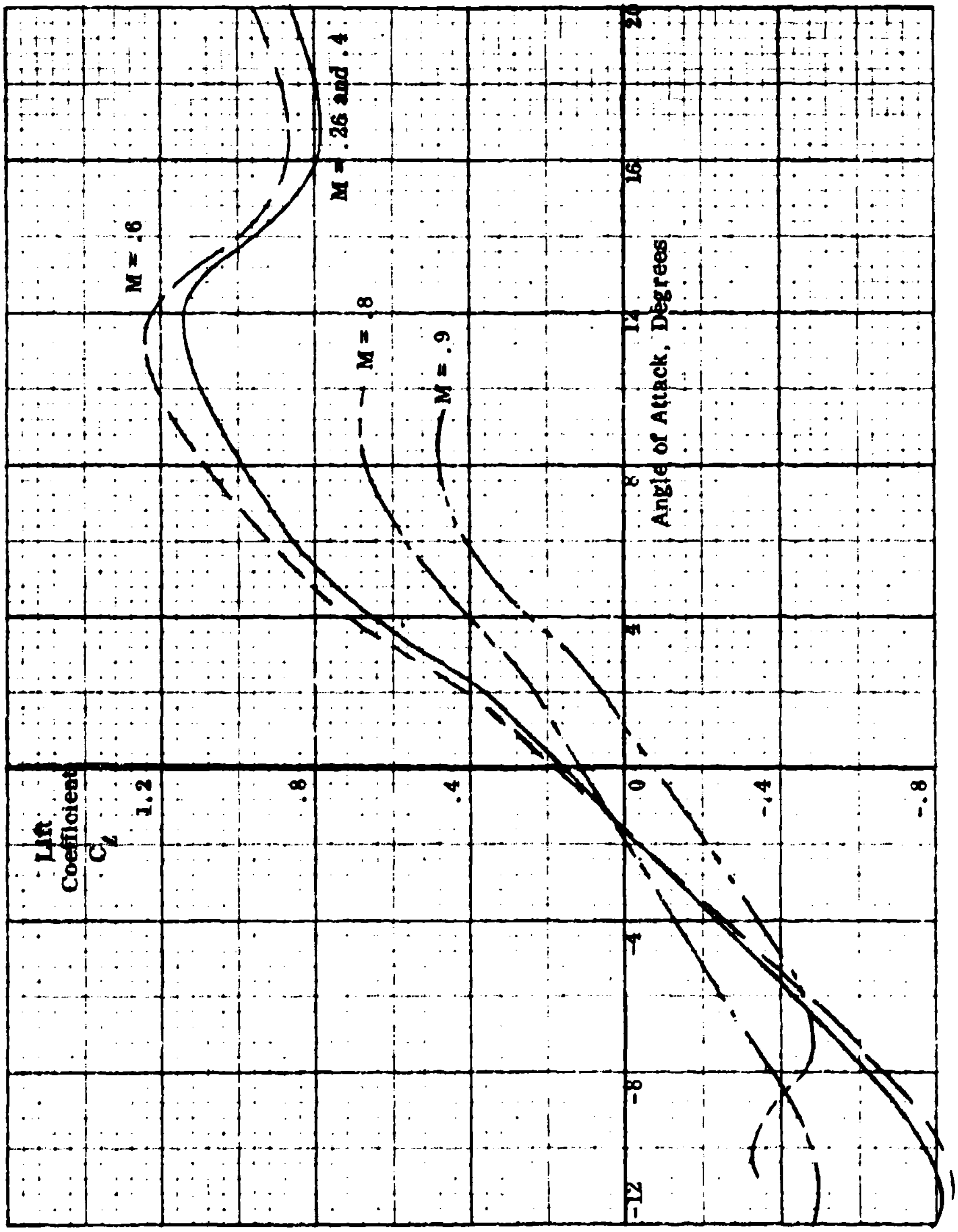


Figure D. 8

SECTION LIFT COEFFICIENT - 12% AIRFOIL, REVERSE MODEL REYNOLDS NUMBER



SECTION LIFT COEFFICIENT THROUGH 360° ANGLE OF ATTACK
12% AIRFOIL - MODEL REYNOLDS NUMBER

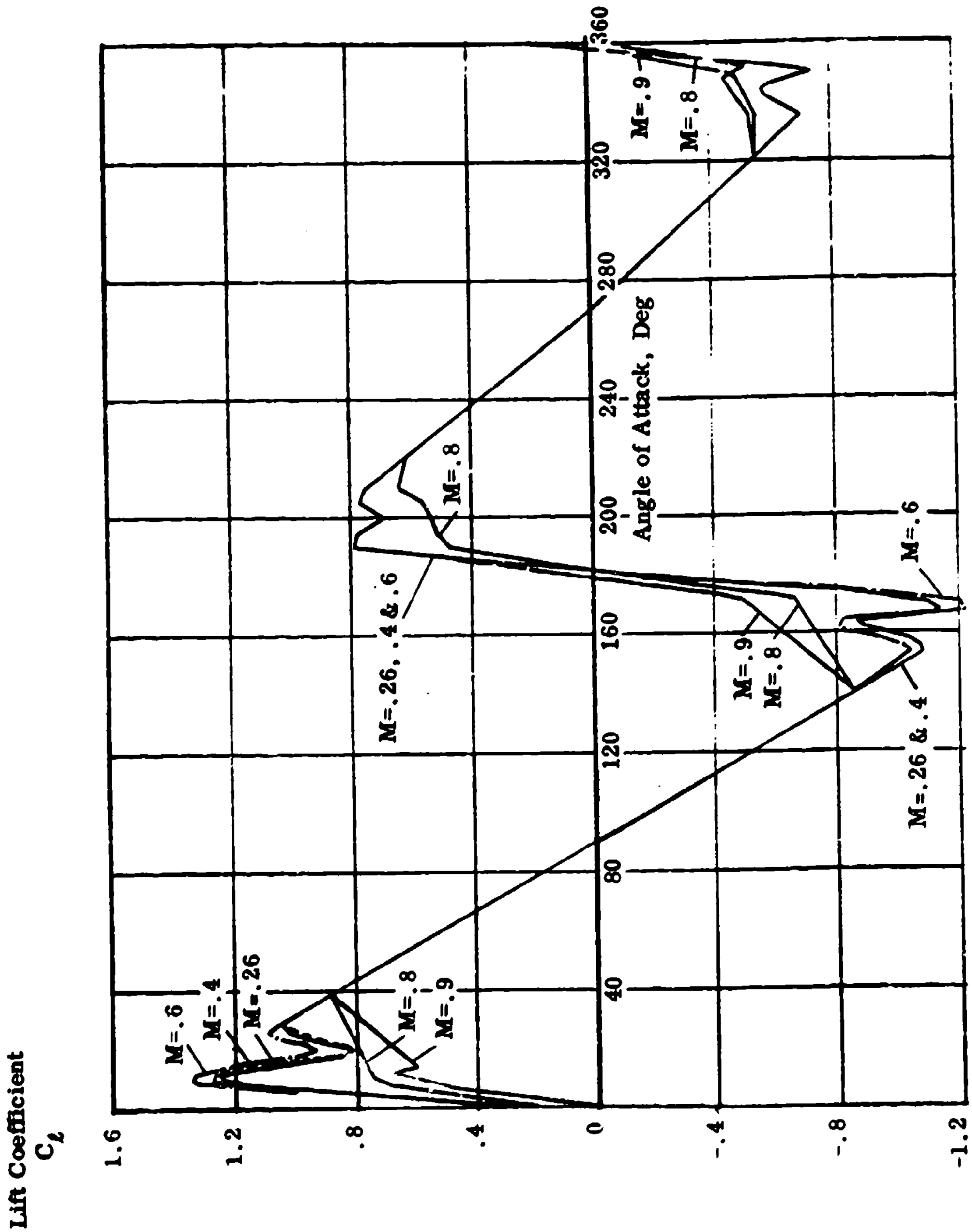


Figure D. 10

SECTION DRAG COEFFICIENT - 12% AIRFOIL, FORWARD
MODEL REYNOLDS NUMBER

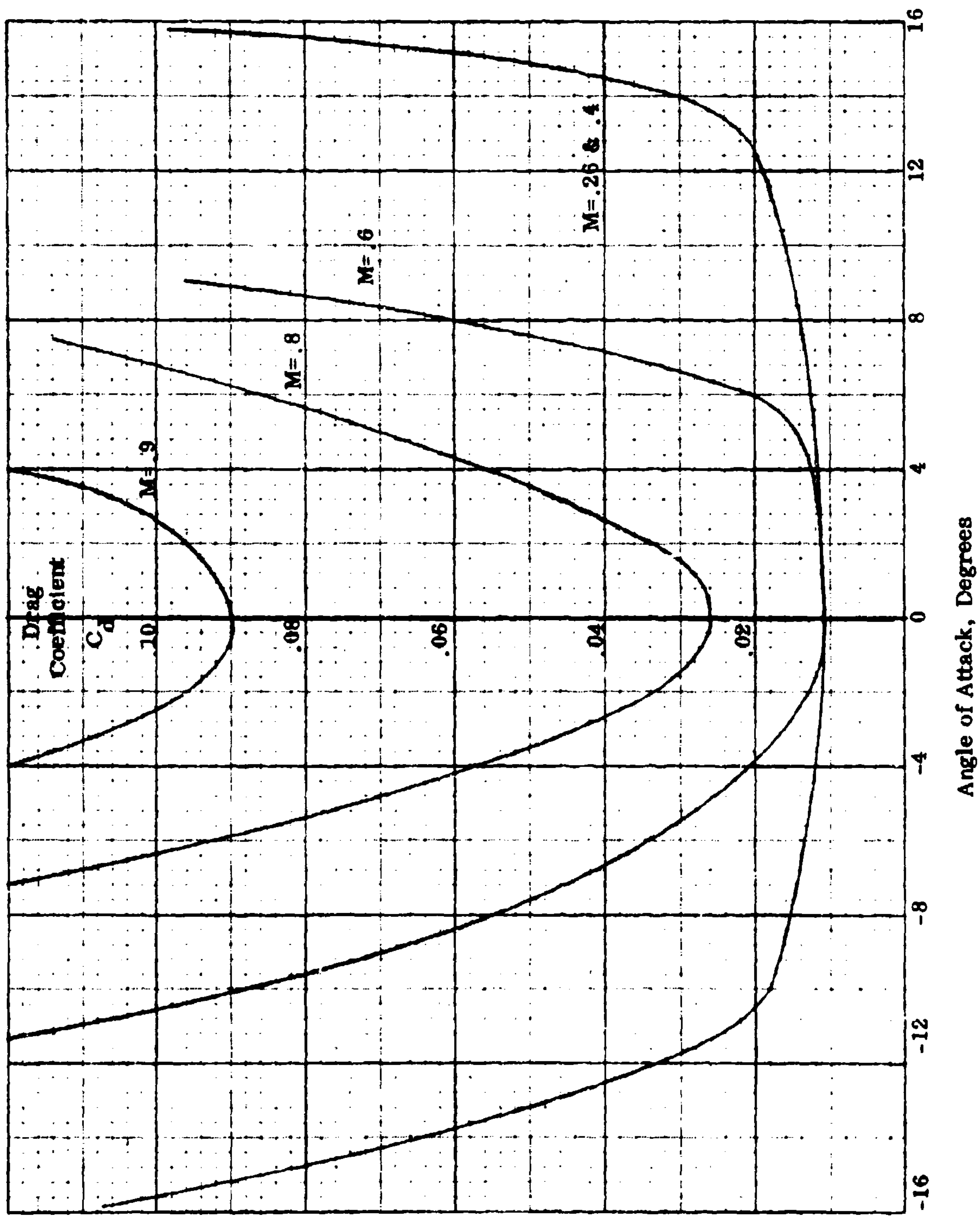
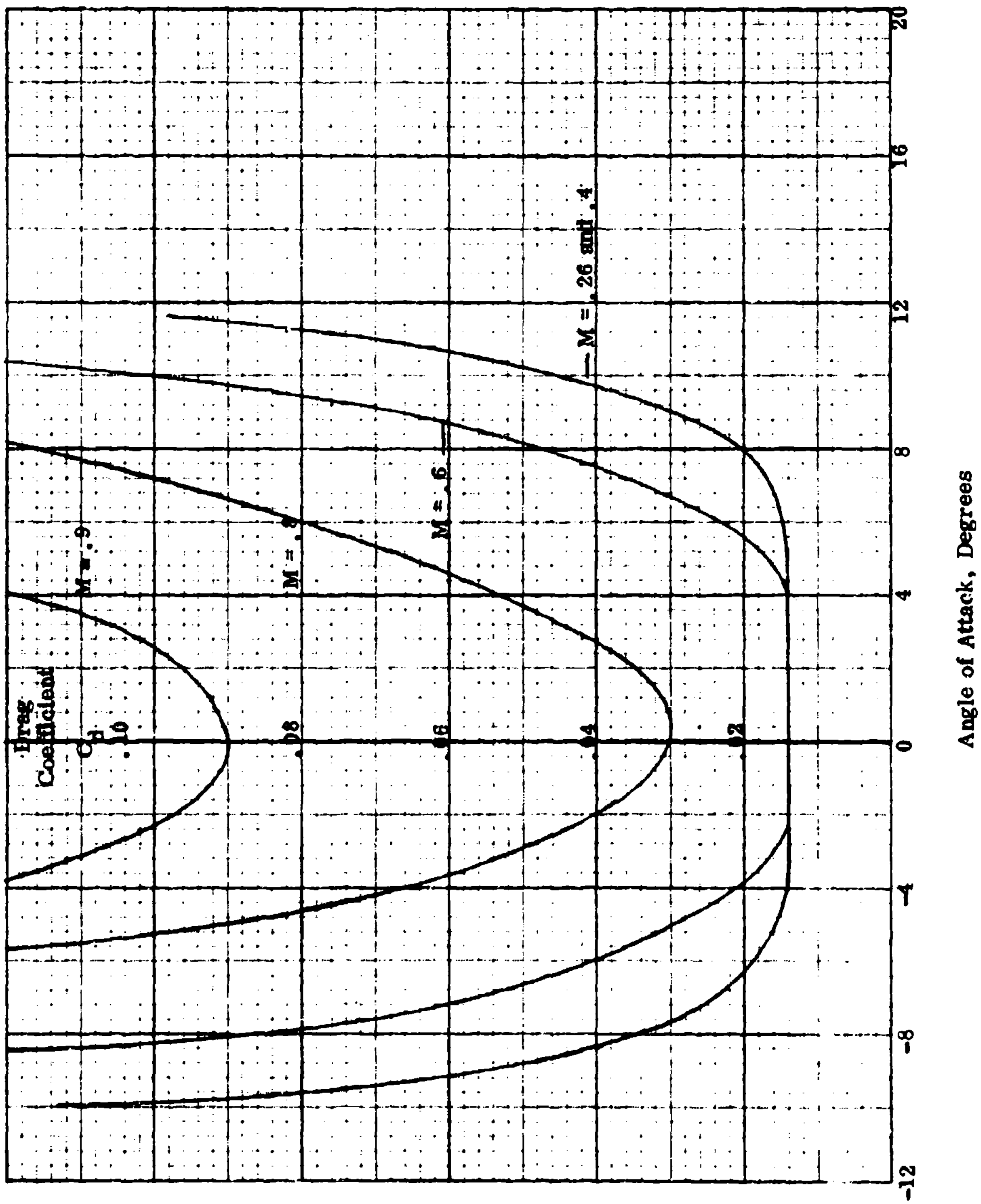


Figure D.11

SECTION DRAG COEFFICIENT - 12% AIRFOIL, REVERSE
MODEL REYNOLDS NUMBER



SECTION DRAG COEFFICIENT THROUGH 360° ANGLE OF ATTACK
12% AIRFOIL - MODEL REYNOLDS NUMBER

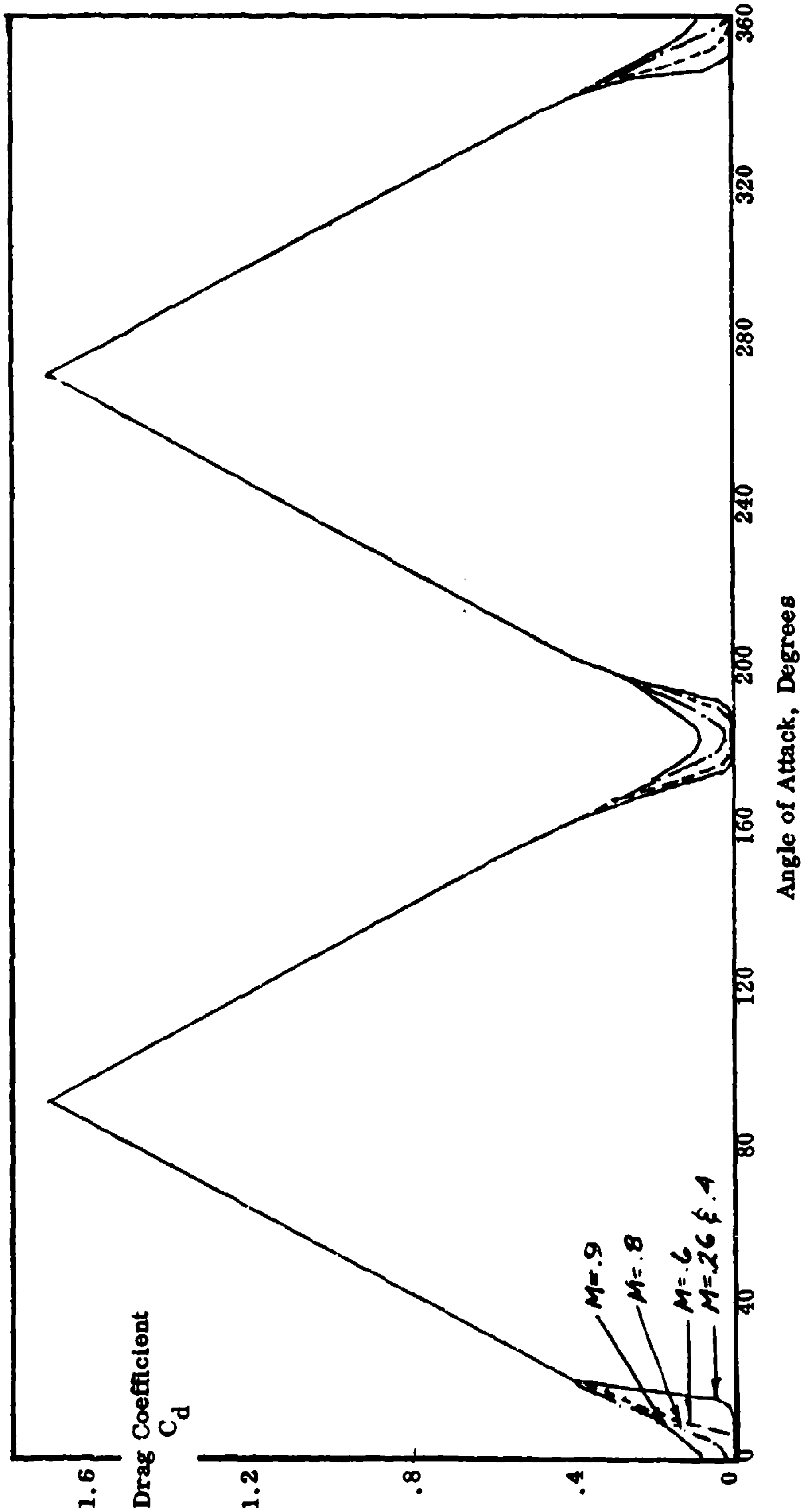


Figure D.13

SECTION LIFT COEFFICIENT - 18% AIRFOIL, FORWARD
MODEL REYNOLDS NUMBER

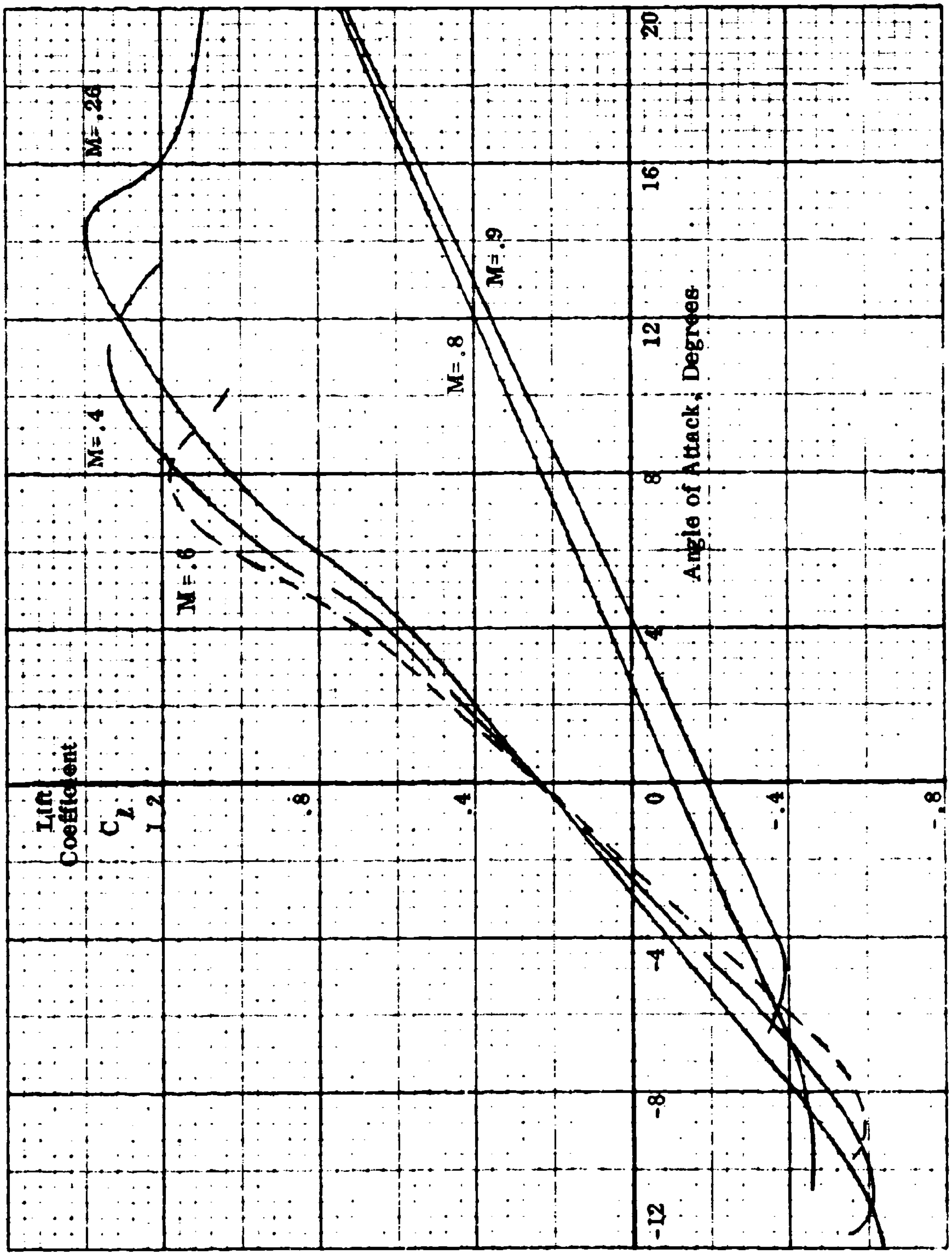
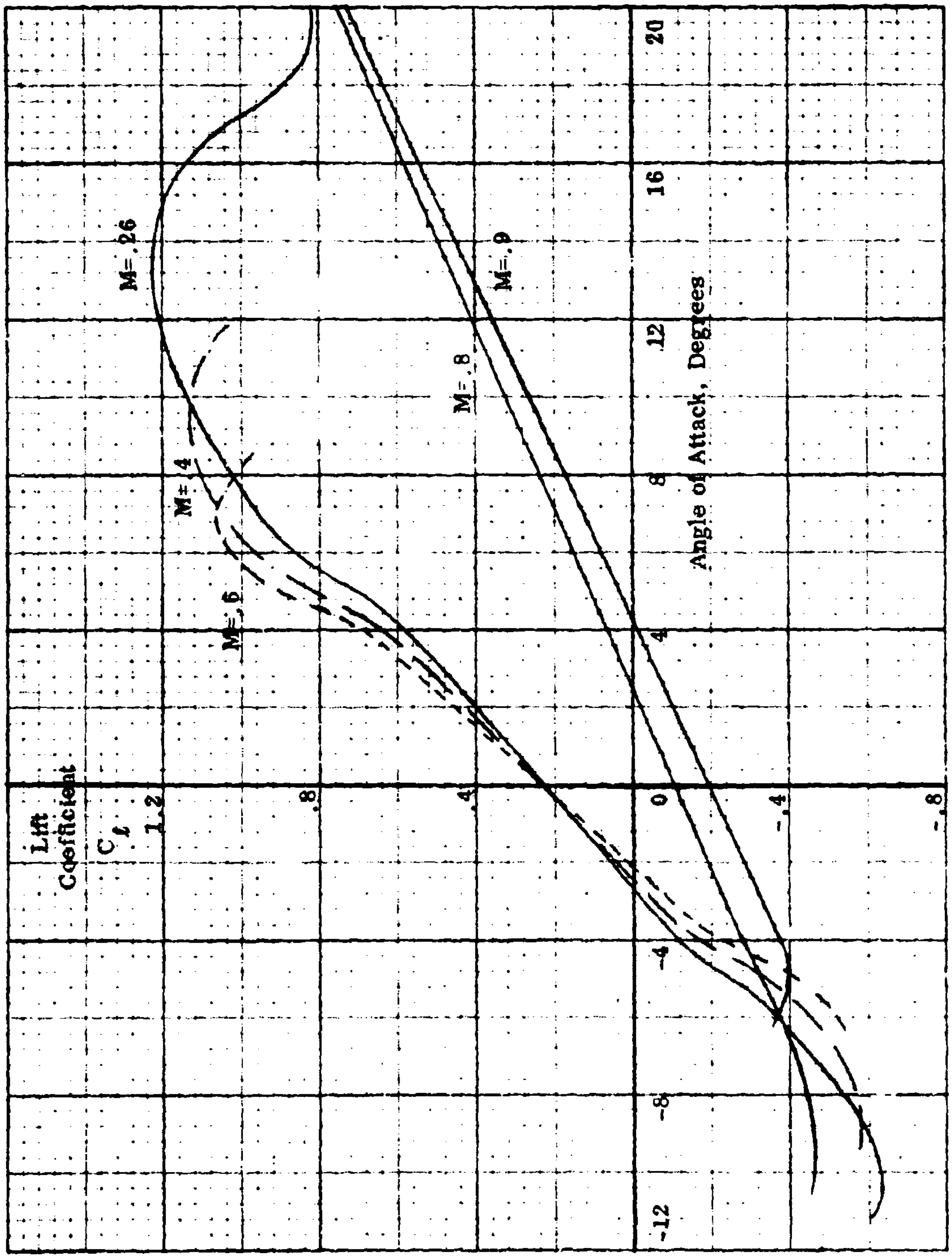


Figure D.14

SECTION LIFT COEFFICIENT - 18% AIRFOIL, REVERSE MODEL REYNOLDS NUMBER



SECTION LIFT COEFFICIENT THROUGH 360° ANGLE OF ATTACK
18% AIRFOIL - MODEL REYNOLDS NUMBER

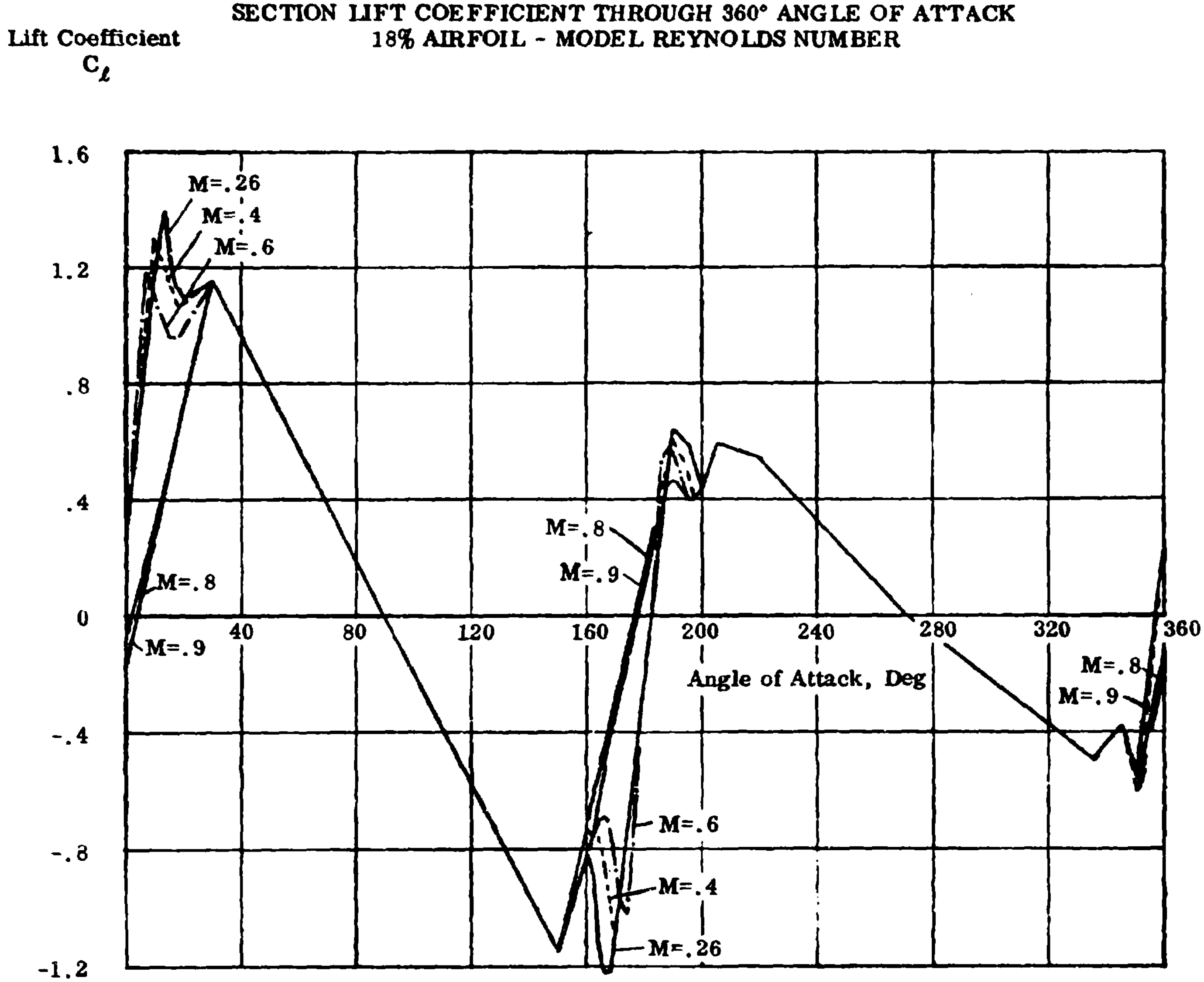


Figure D.16

SECTION DRAG COEFFICIENT - 18% AIRFOIL, FORWARD
MODEL REYNOLDS NUMBER

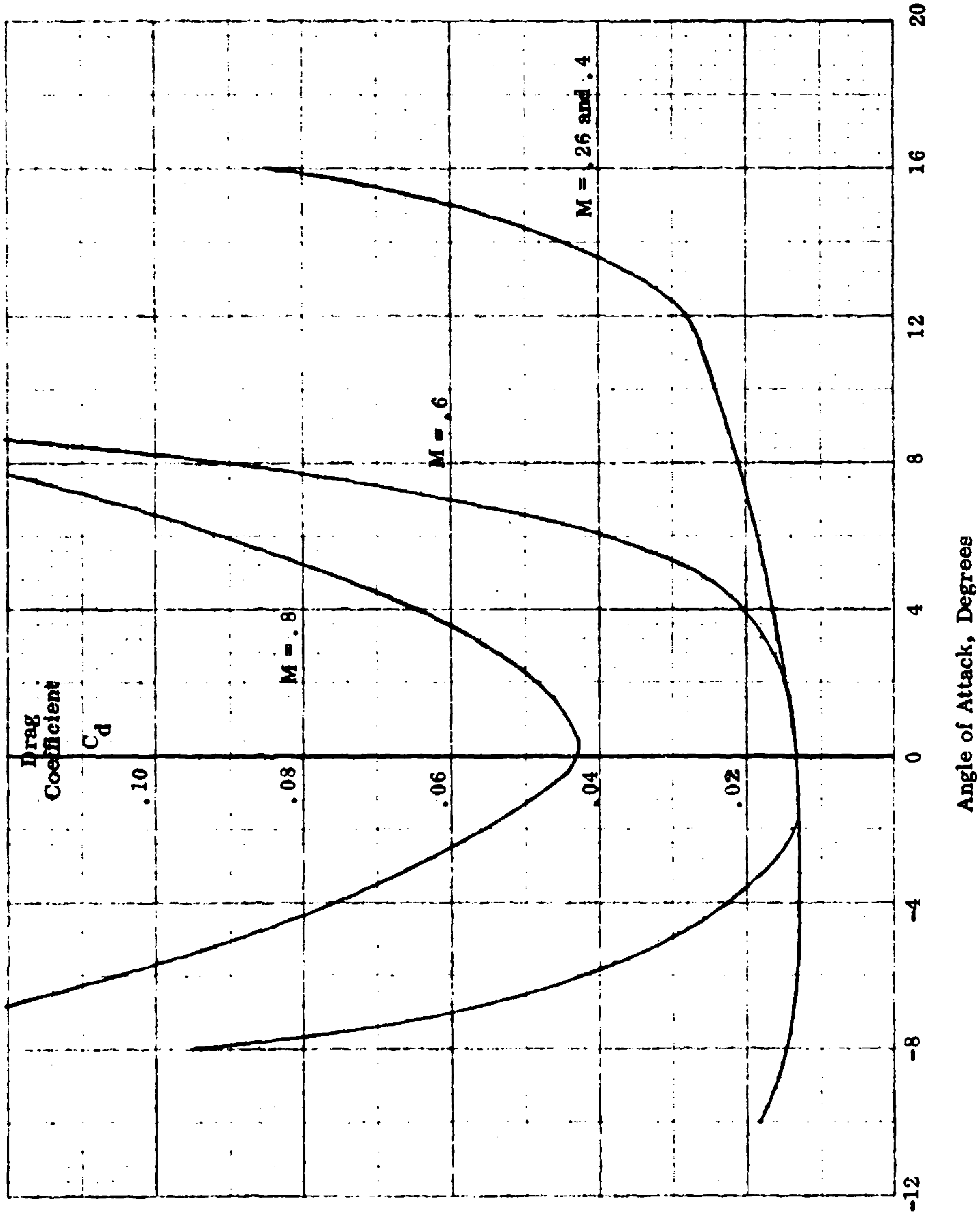


Figure D.17

SECTION DRAG COEFFICIENT - 18% AIRFOIL, REVERSE
MODEL REYNOLDS NUMBER

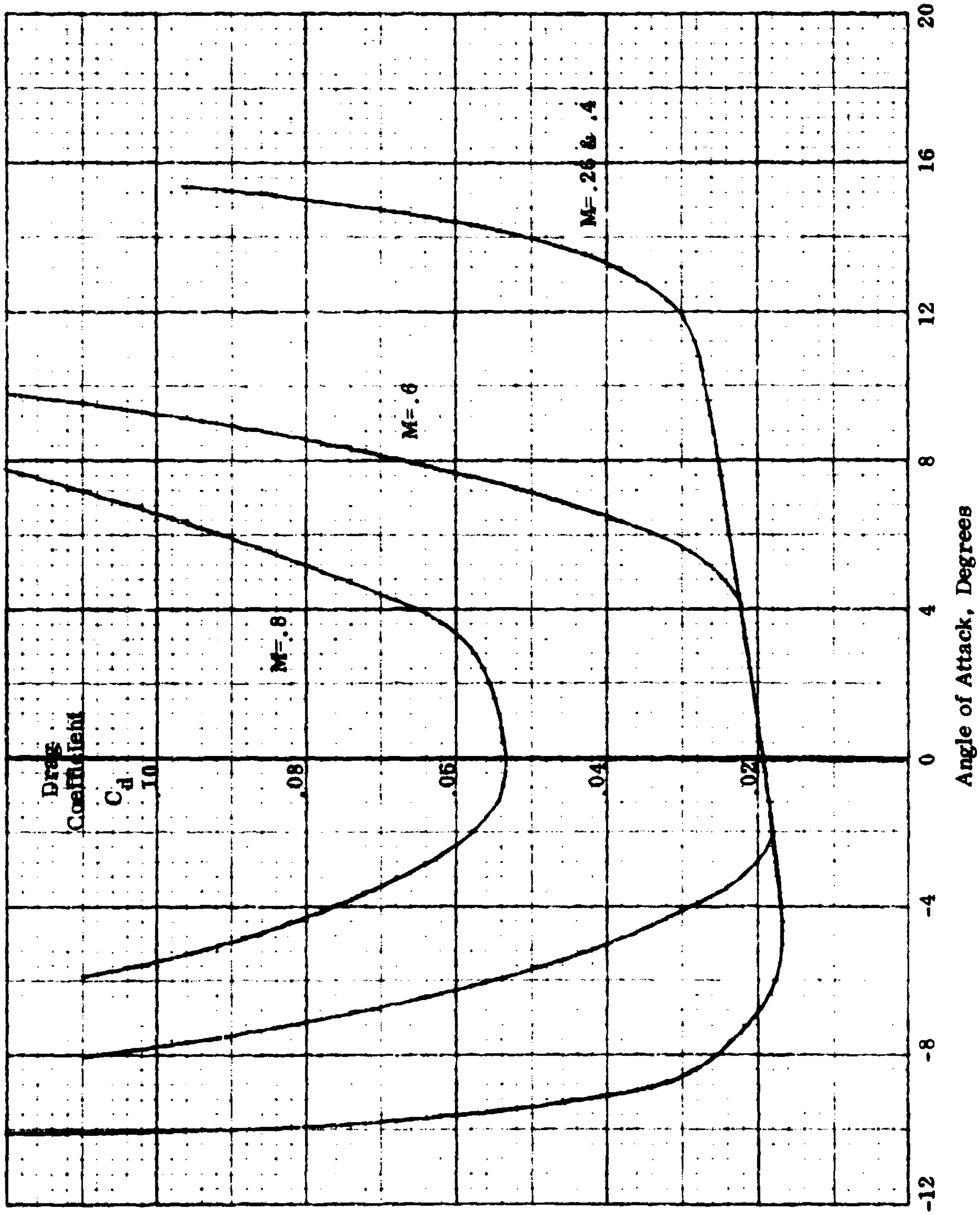


Figure D.18

SECTION DRAG COEFFICIENT THROUGH 360° ANGLE OF ATTACK
18% AIRFOIL - MODEL REYNOLDS NUMBER

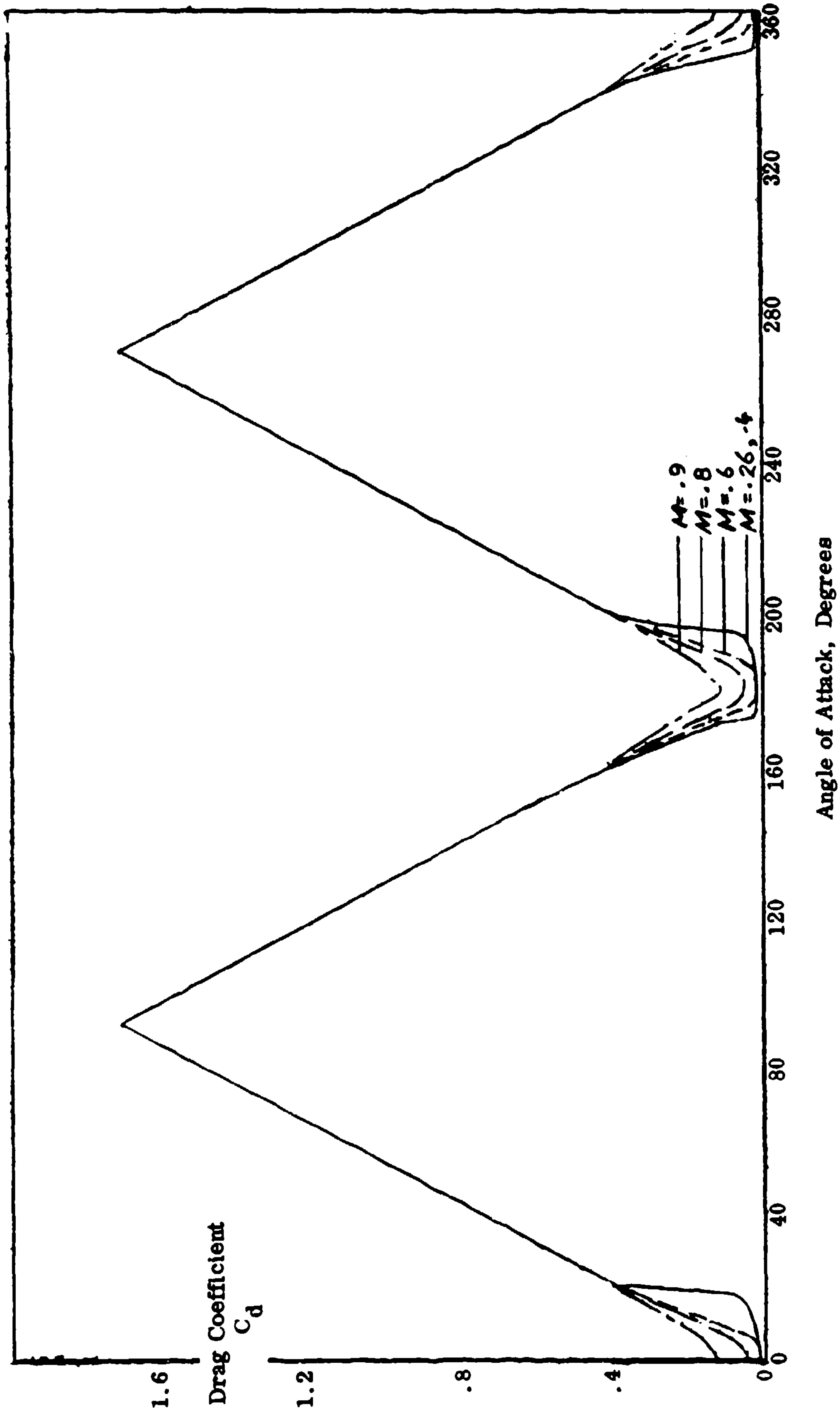


Figure D.19

SECTION LIFT COEFFICIENT - 6% AIRFOIL, FORWARD
FULL SCALE REYNOLDS NUMBER

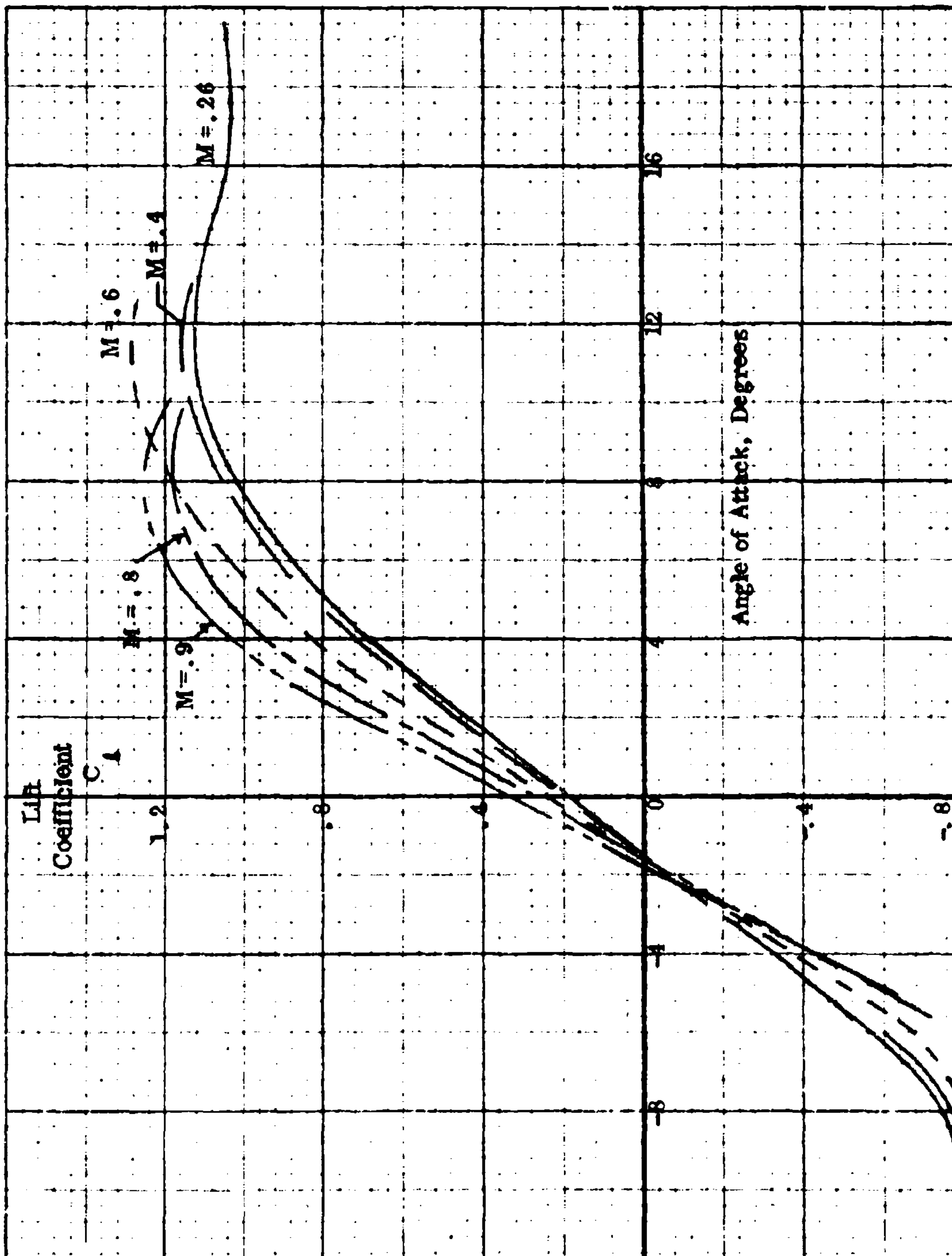
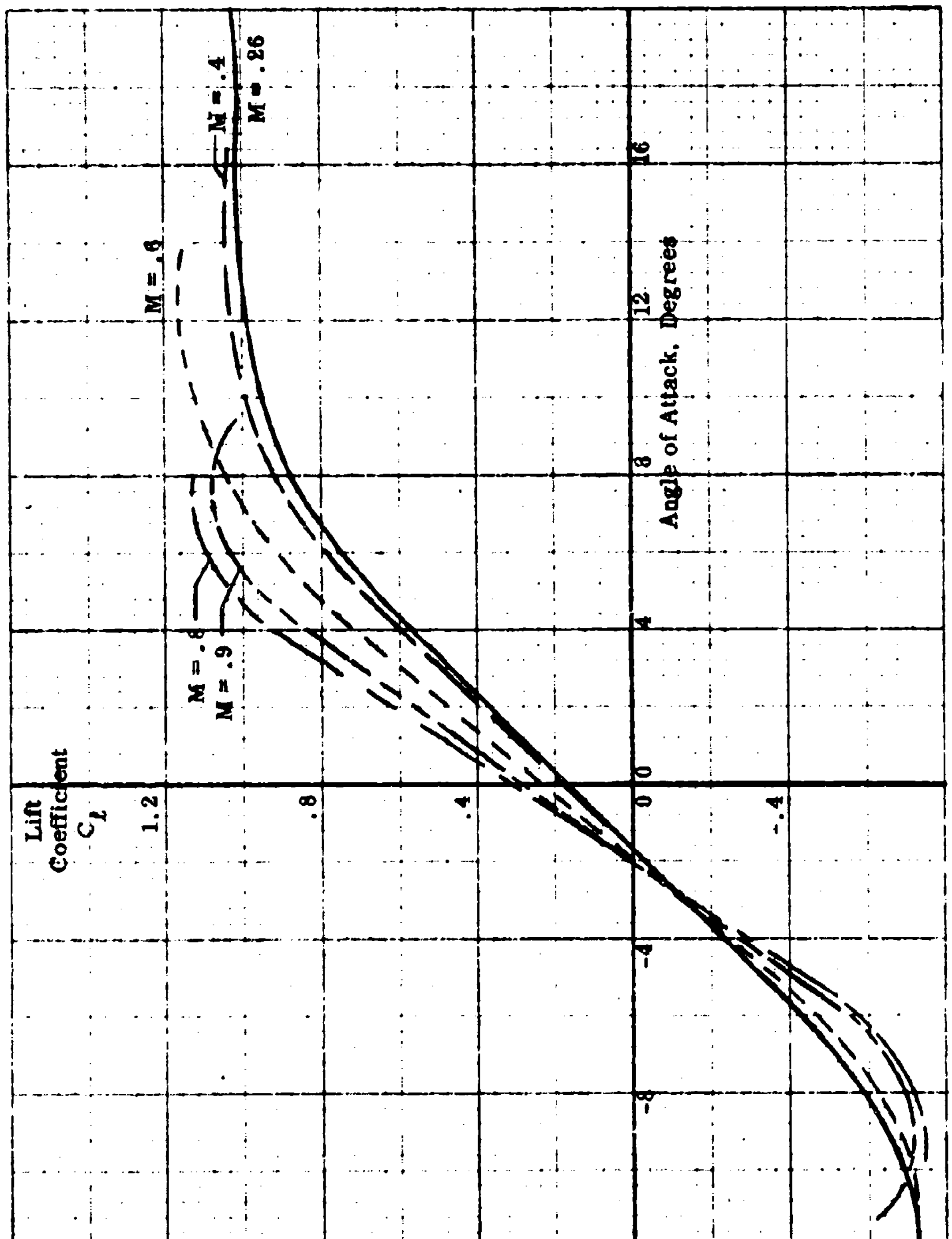


Figure D.20

SECTION LIFT COEFFICIENT - 6% AIRFOIL, REVERSE
FULL SCALE REYNOLDS NUMBER



SECTION LIFT COEFFICIENT THROUGH 360° ANGLE OF ATTACK
6% AIRFOIL - FULL SCALE REYNOLDS NUMBER

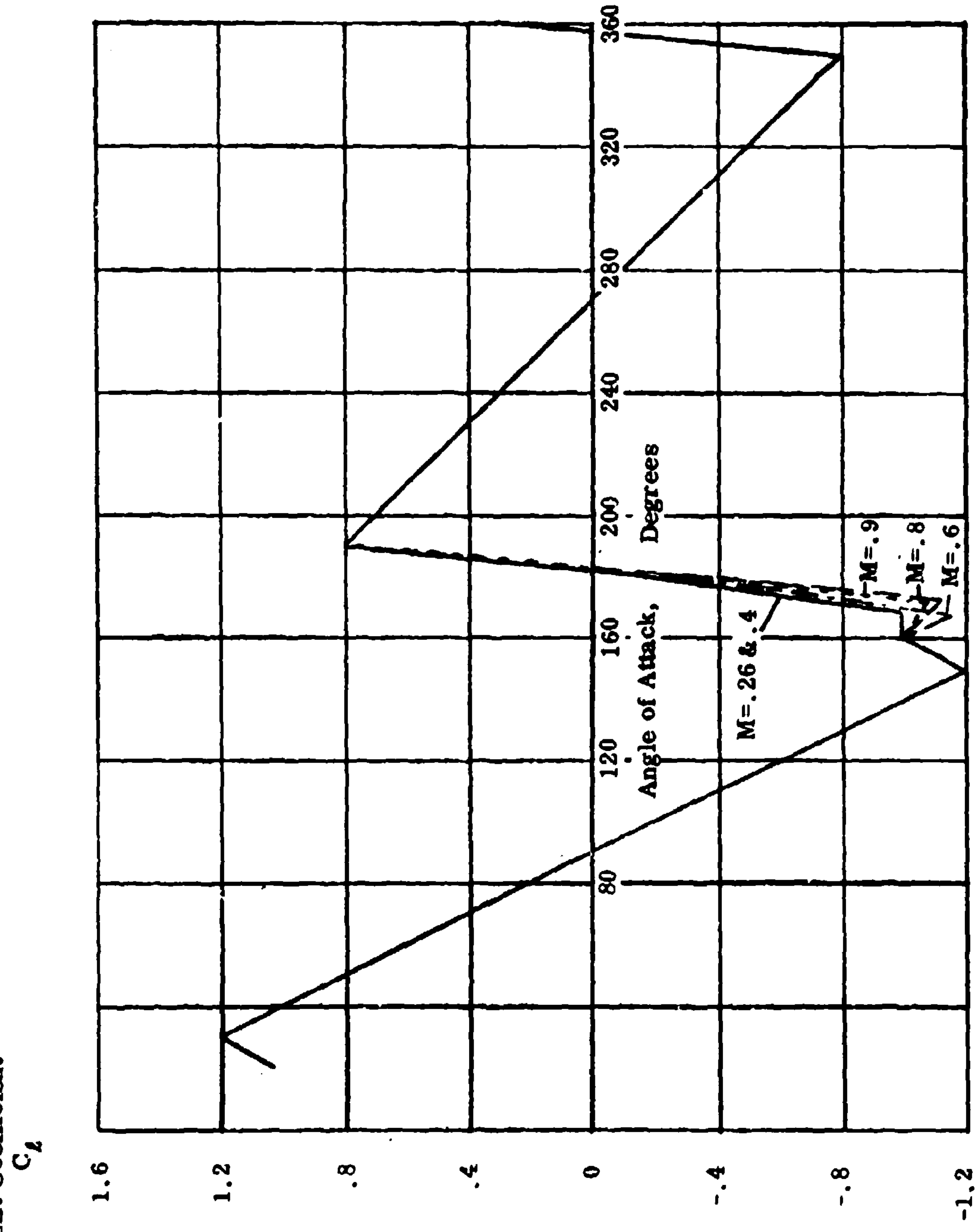


Figure D.22

SECTION DRAG COEFFICIENT - 6% AIRFOIL, FORWARD
FULL SCALE REYNOLDS NUMBER

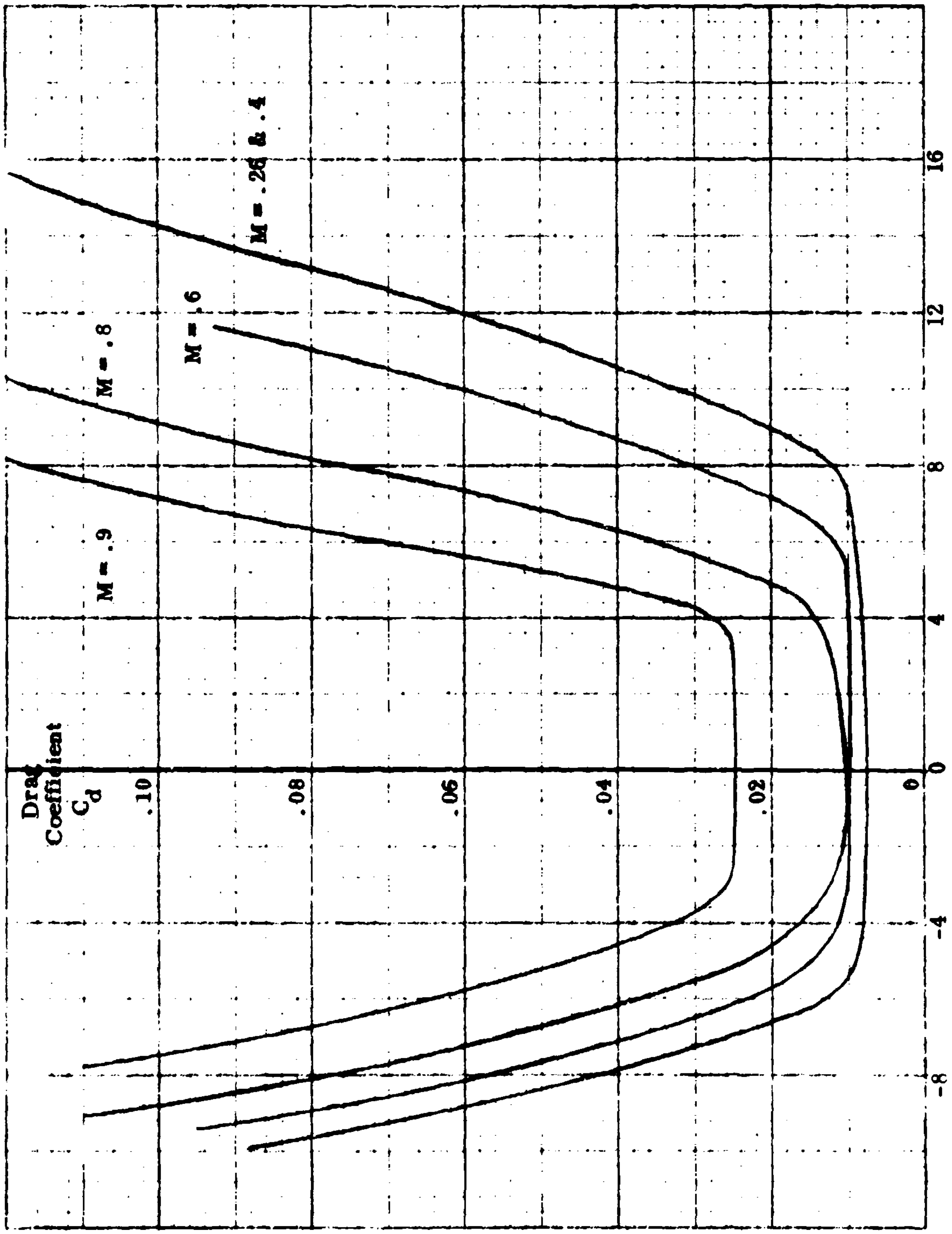
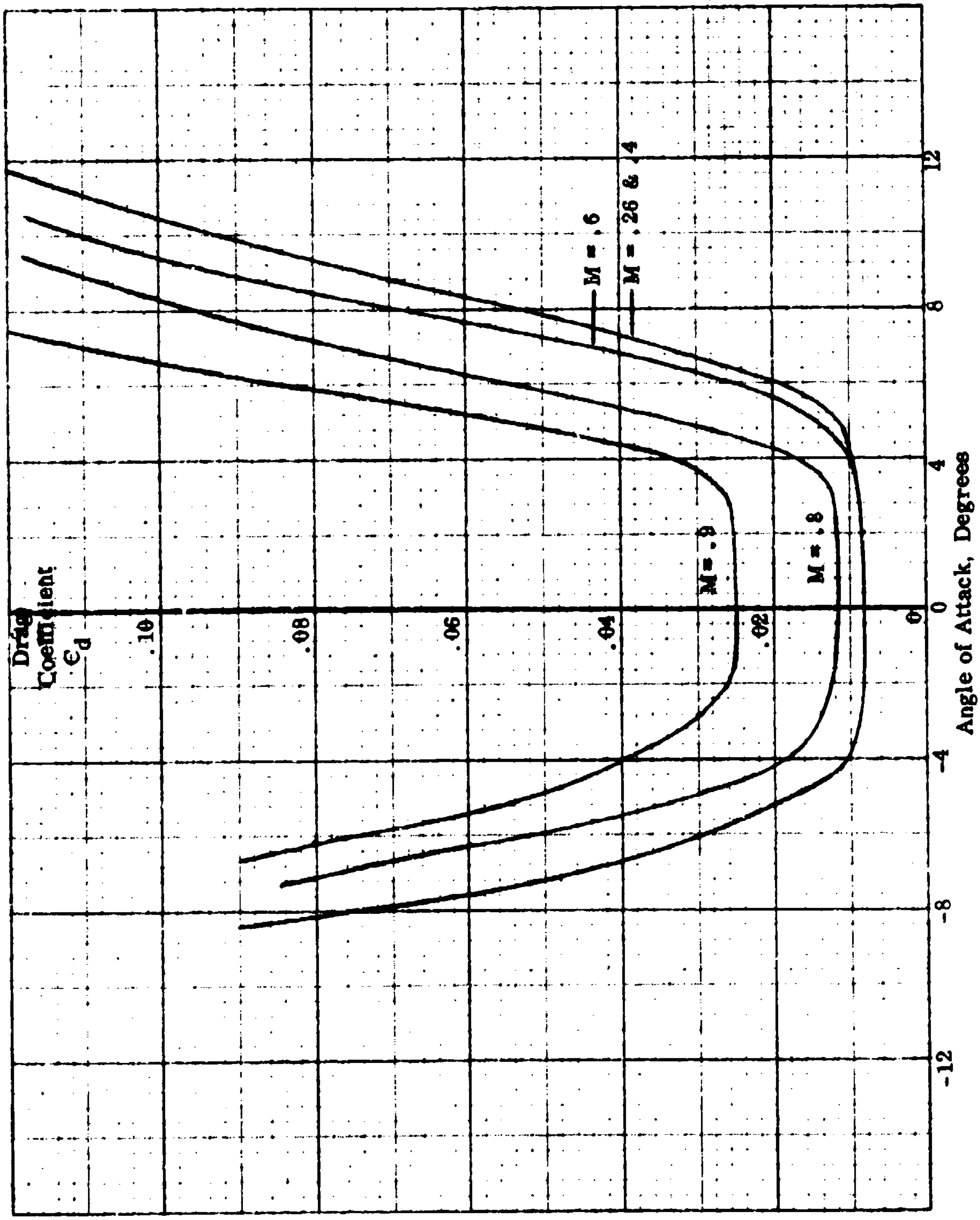


Figure D.23

SECTION DRAG COEFFICIENT - 6% AIRFOIL, REVERSE FULL SCALE REYNOLDS NUMBER



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6% AIRFOIL - FULL SCALE REYNOLDS NUMBER

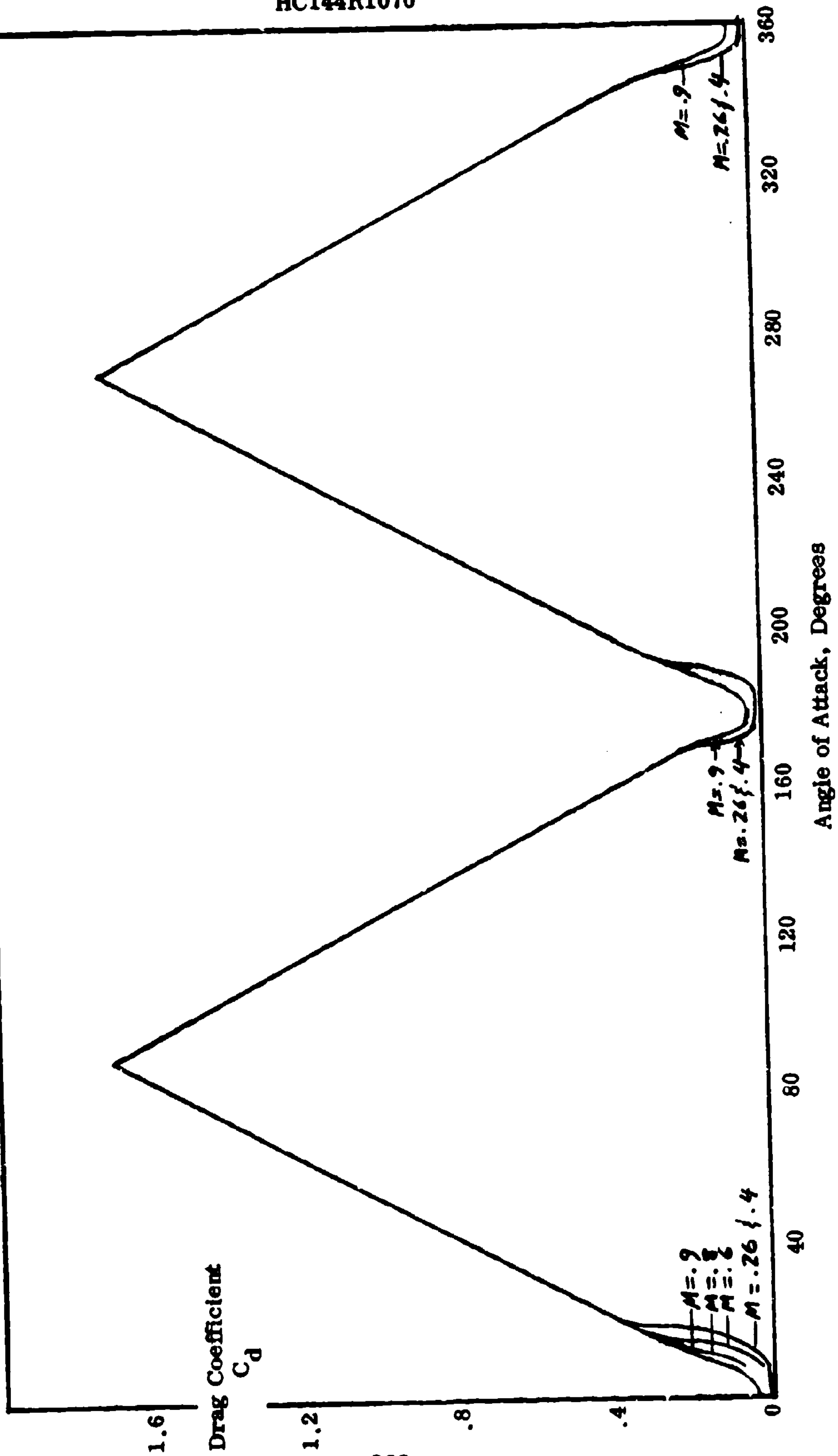

Figure D.25

SECTION LIFT COEFFICIENT - 12% AIRFOIL, FORWARD FULL SCALE REYNOLDS NUMBER

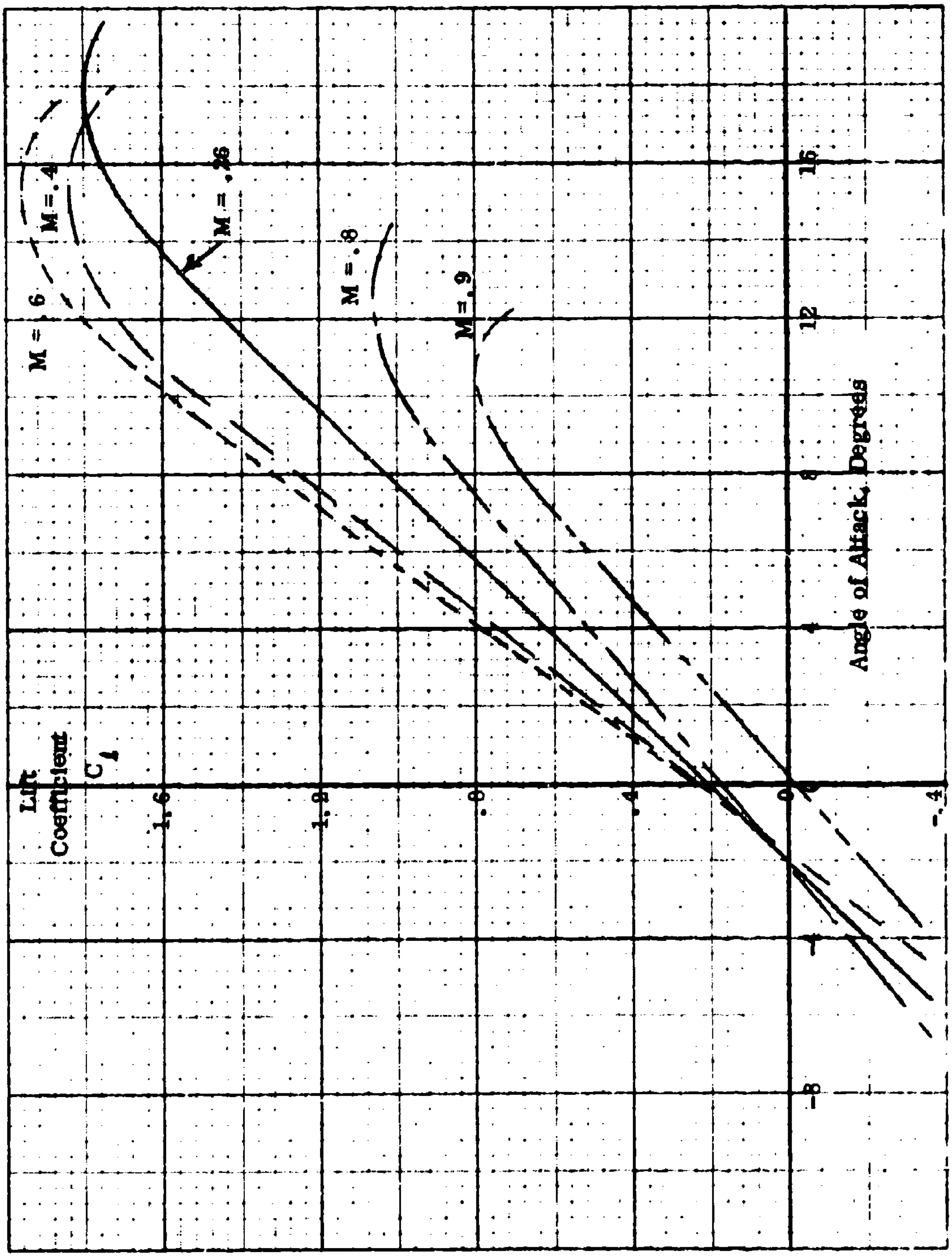

Figure D. 26

SECTION LIFT COEFFICIENT - 12% AIRFOIL, REVERSE
FULL SCALE REYNOLDS NUMBER

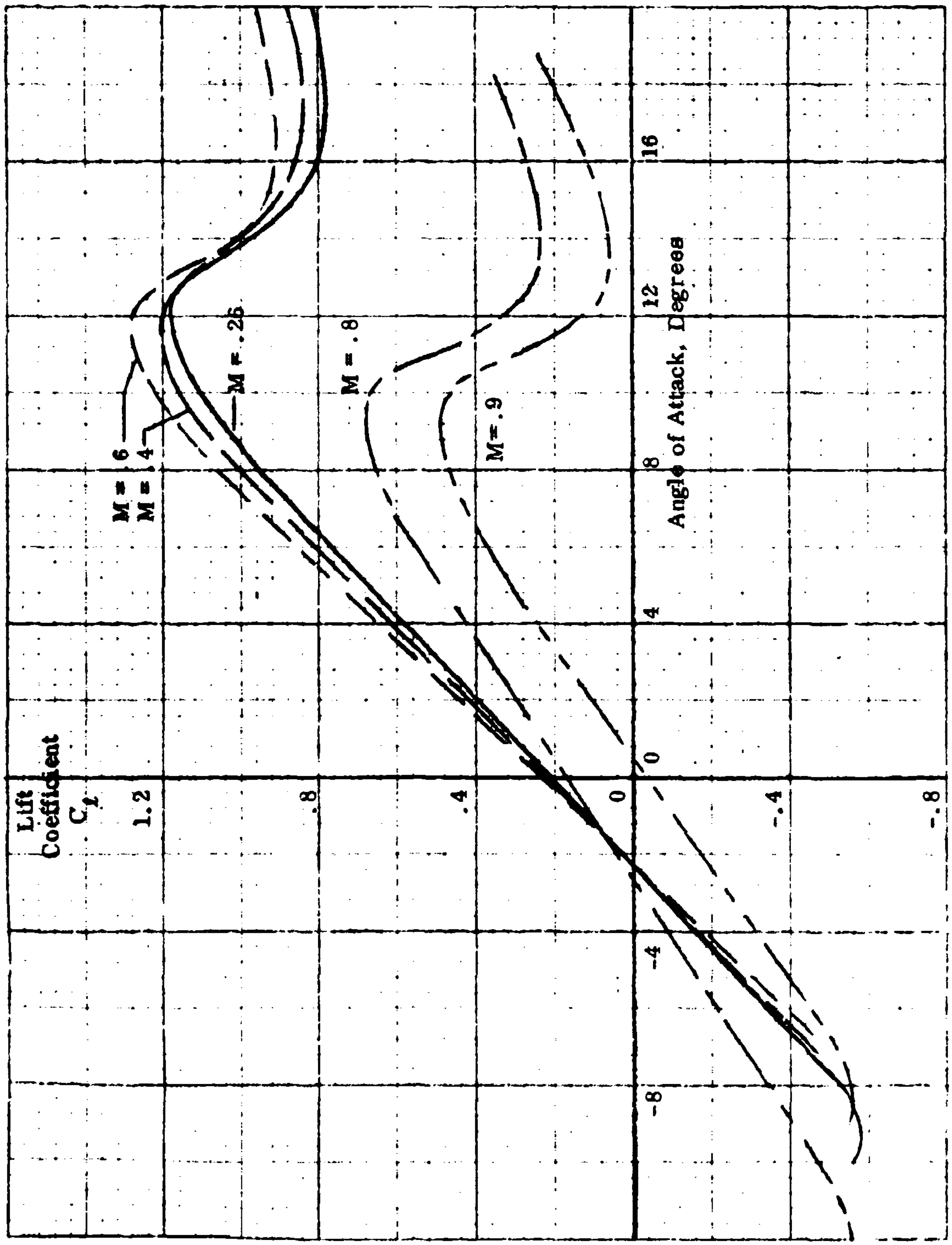

Figure D.27

SECTION LIFT COEFFICIENT THROUGH 360° ANGLE OF ATTACK
12% AIRFOIL - FULL SCALE REYNOLDS NUMBER

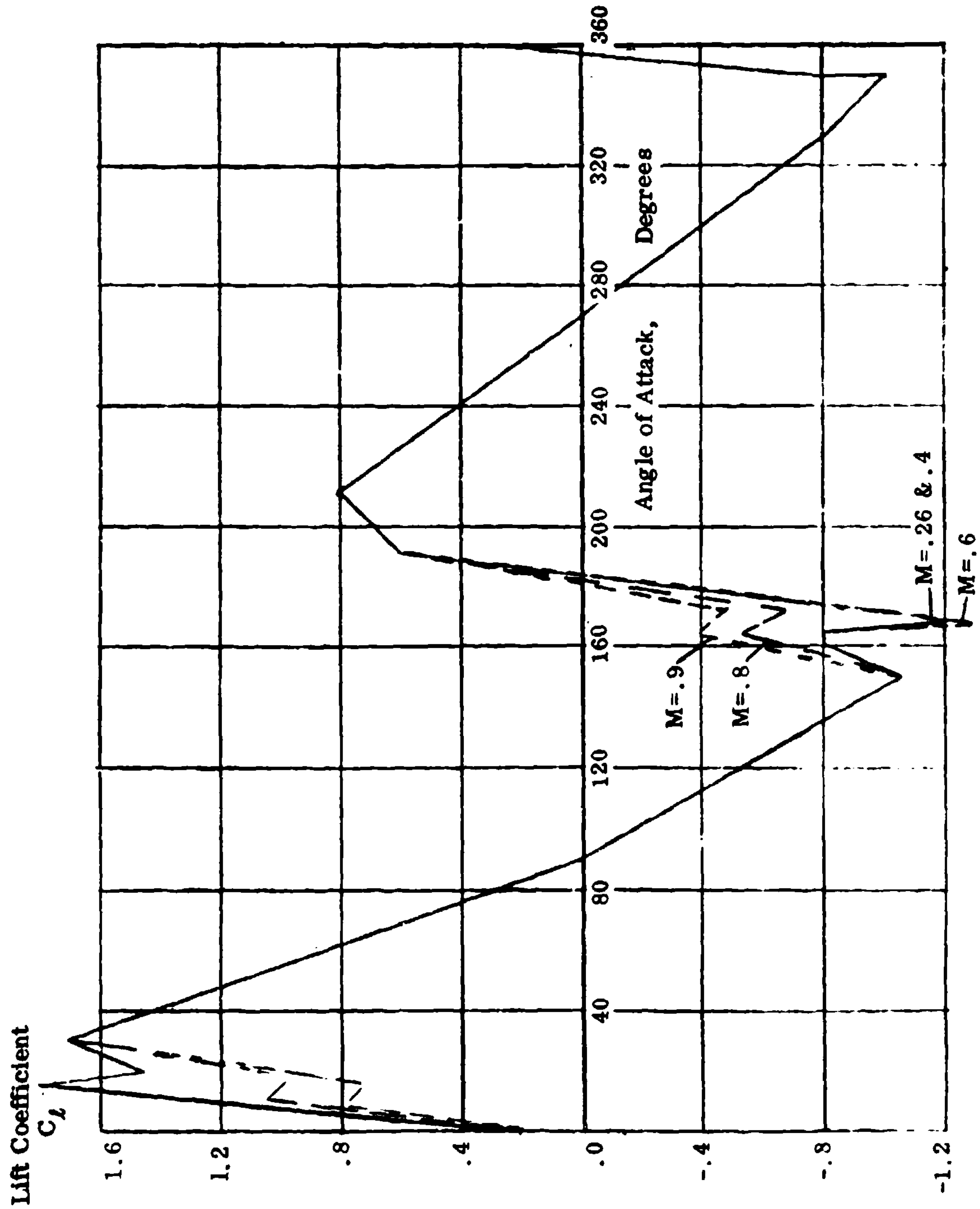

Figure D.28

SECTION DRAG COEFFICIENT - 12% AIRFOIL, FORWARD
FULL SCALE REYNOLDS NUMBER

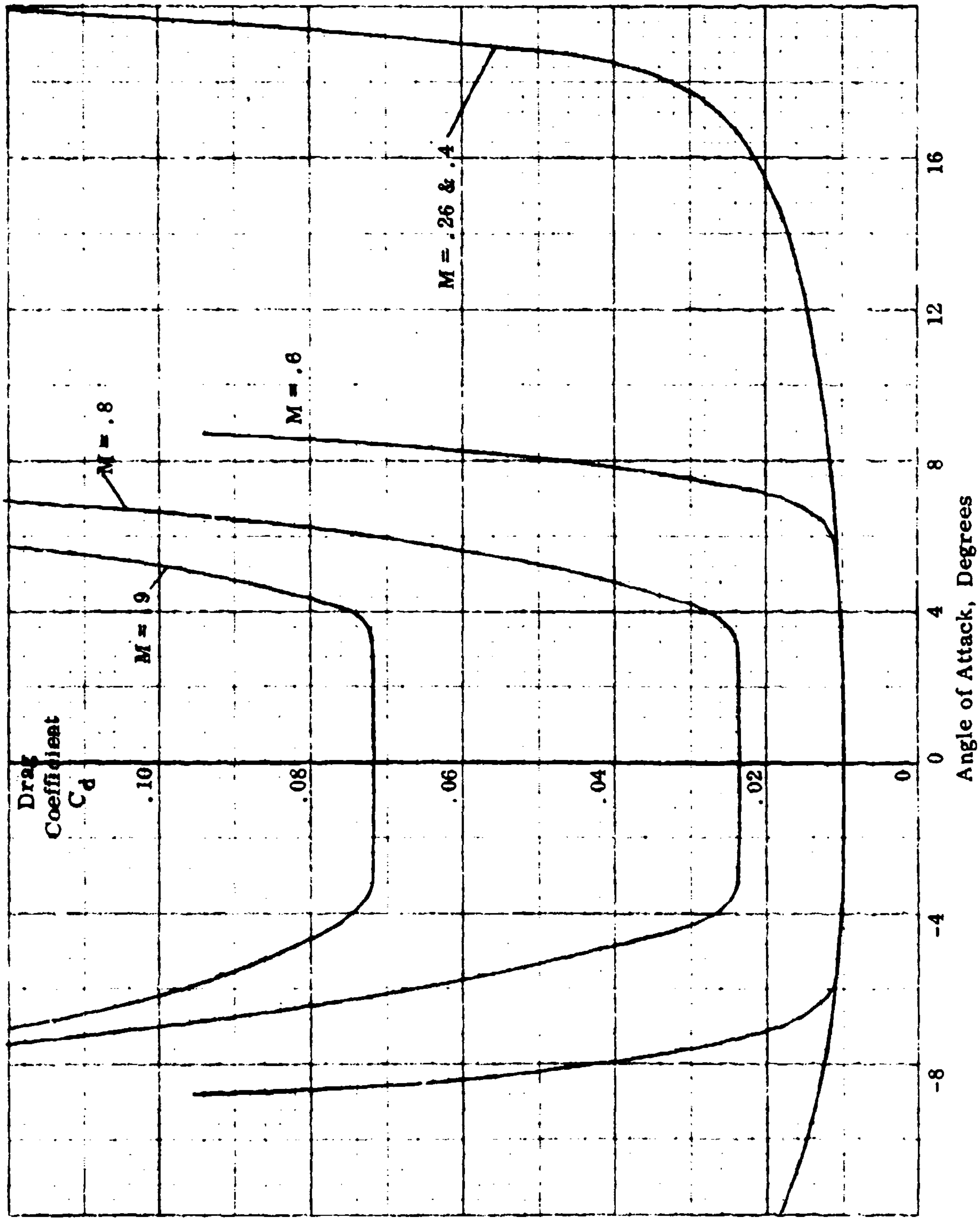

Figure D.29

SECTION DRAG COEFFICIENT - 12% AIRFOIL, REVERSE
FULL SCALE REYNOLDS NUMBER

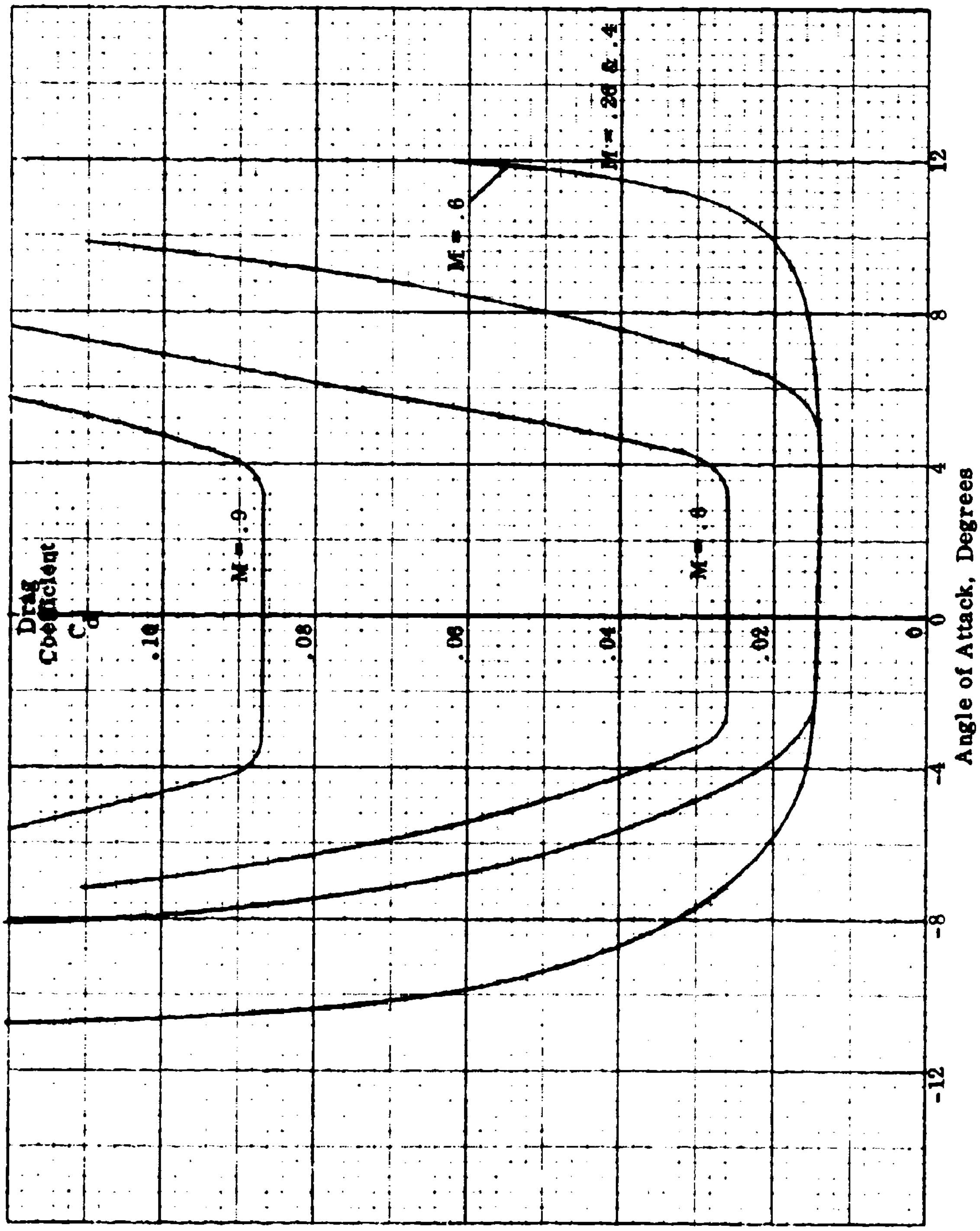

Figure D.30

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SECTION DRAG COEFFICIENT THROUGH 360° ANGLE OF ATTACK
12% AIRFOIL - FULL SCALE REYNOLDS NUMBER

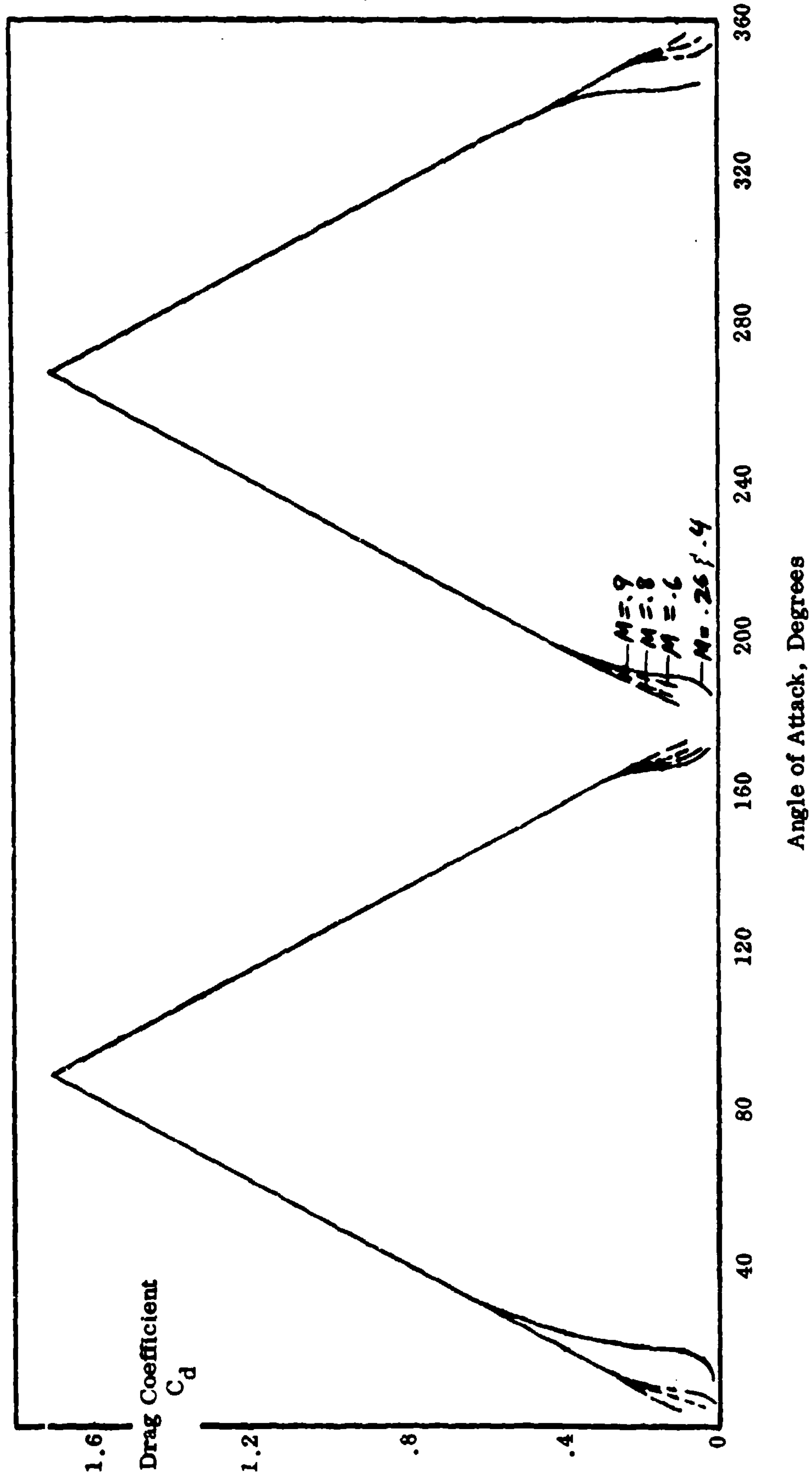


Figure D. 31

SECTION LIFT COEFFICIENT - 18% AIRFOIL, FORWARD
FULL SCALE REYNOLDS NUMBER

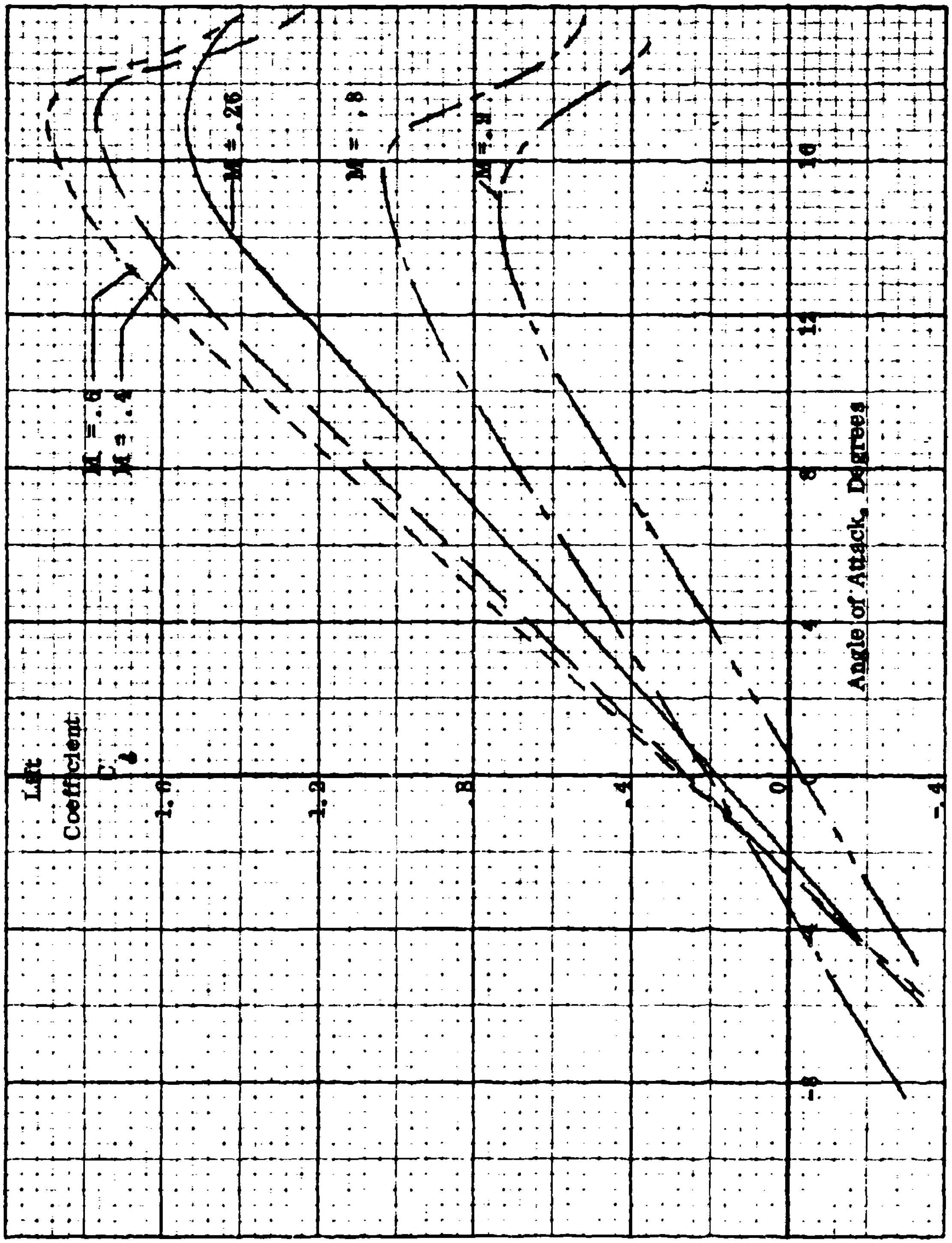
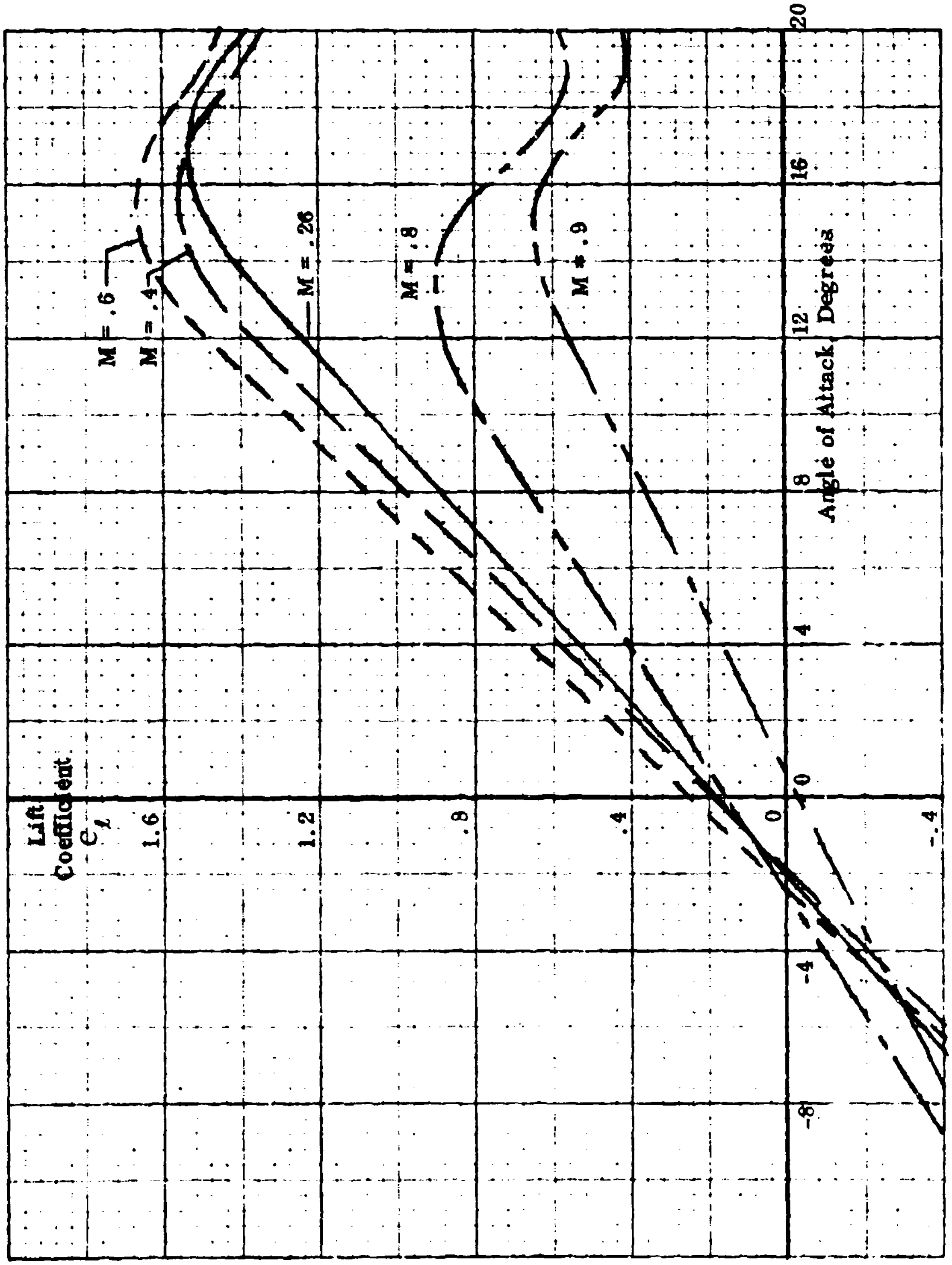


Figure D. 32

SECTION LIFT COEFFICIENT - 18% AIRFOIL, REVERSE FULL SCALE REYNOLDS NUMBER



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18% AIRFOIL - FULL SCALE REYNOLDS NUMBER

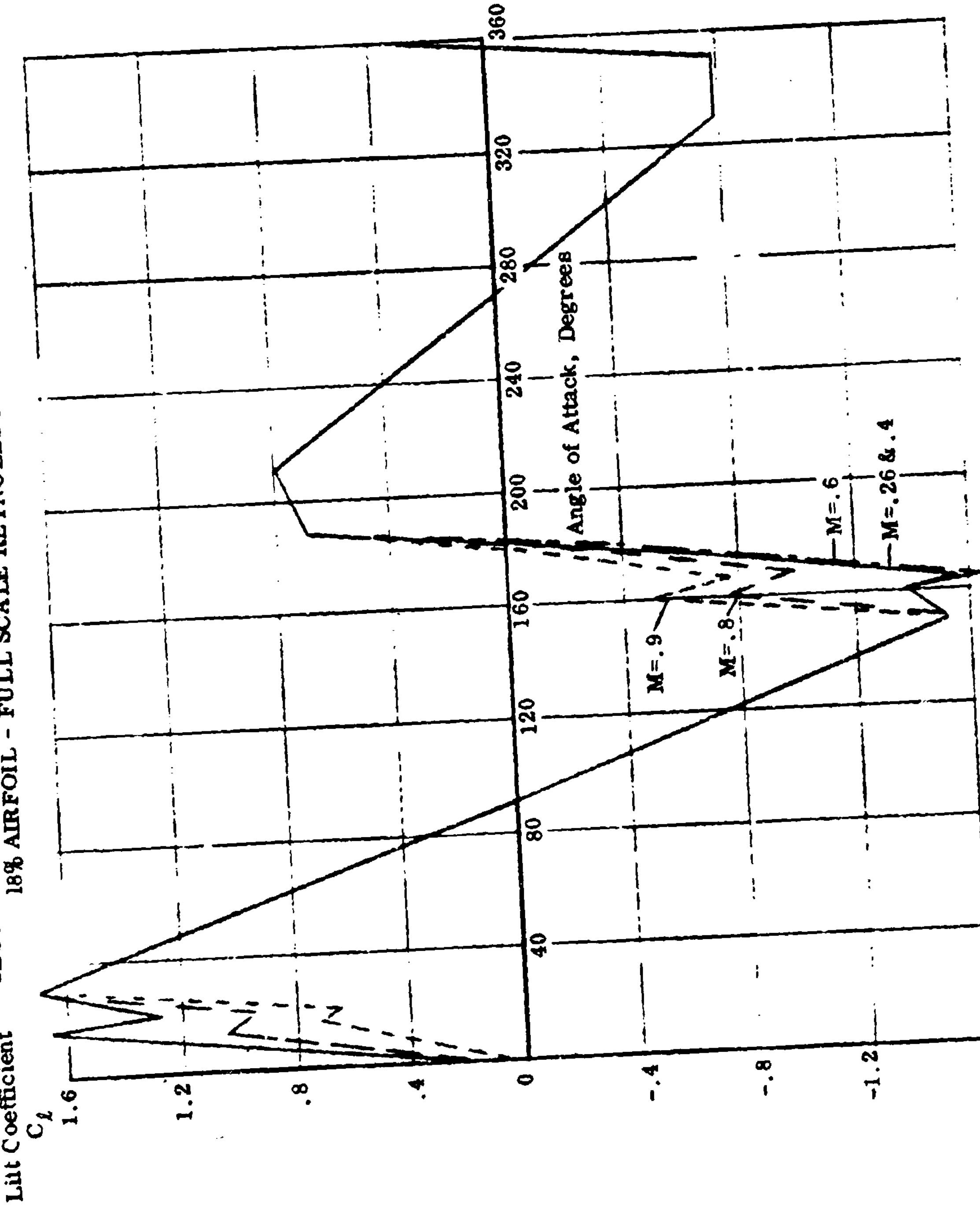

Figure D. 34

SECTION DRAG COEFFICIENT - 18% AIRFOIL, FORWARD FULL SCALE REYNOLDS NUMBER

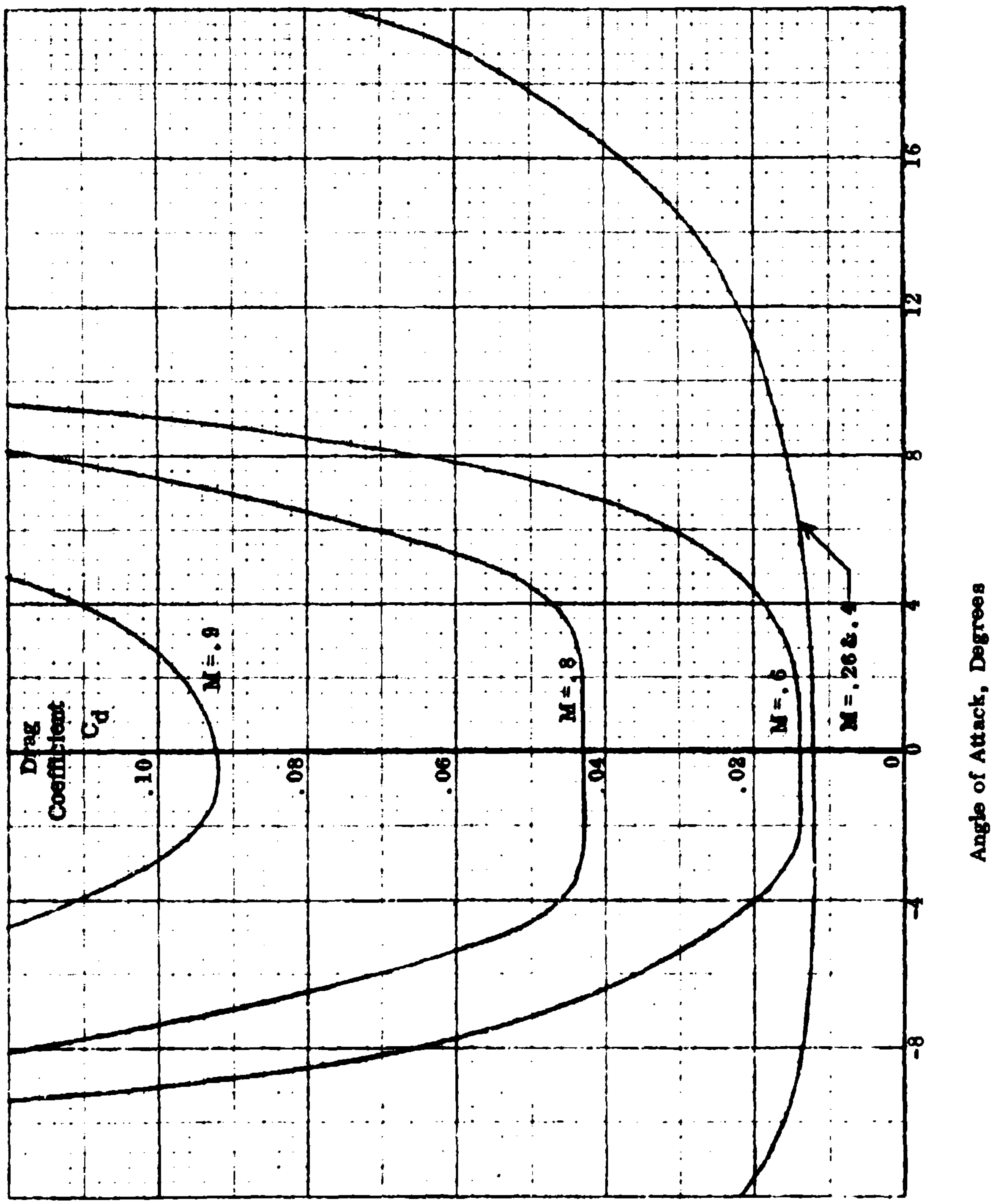

Figure D. 35

SECTION DRAG COEFFICIENT - 18% AIRFOIL, REVERSE
FULL SCALE REYNOLDS NUMBER

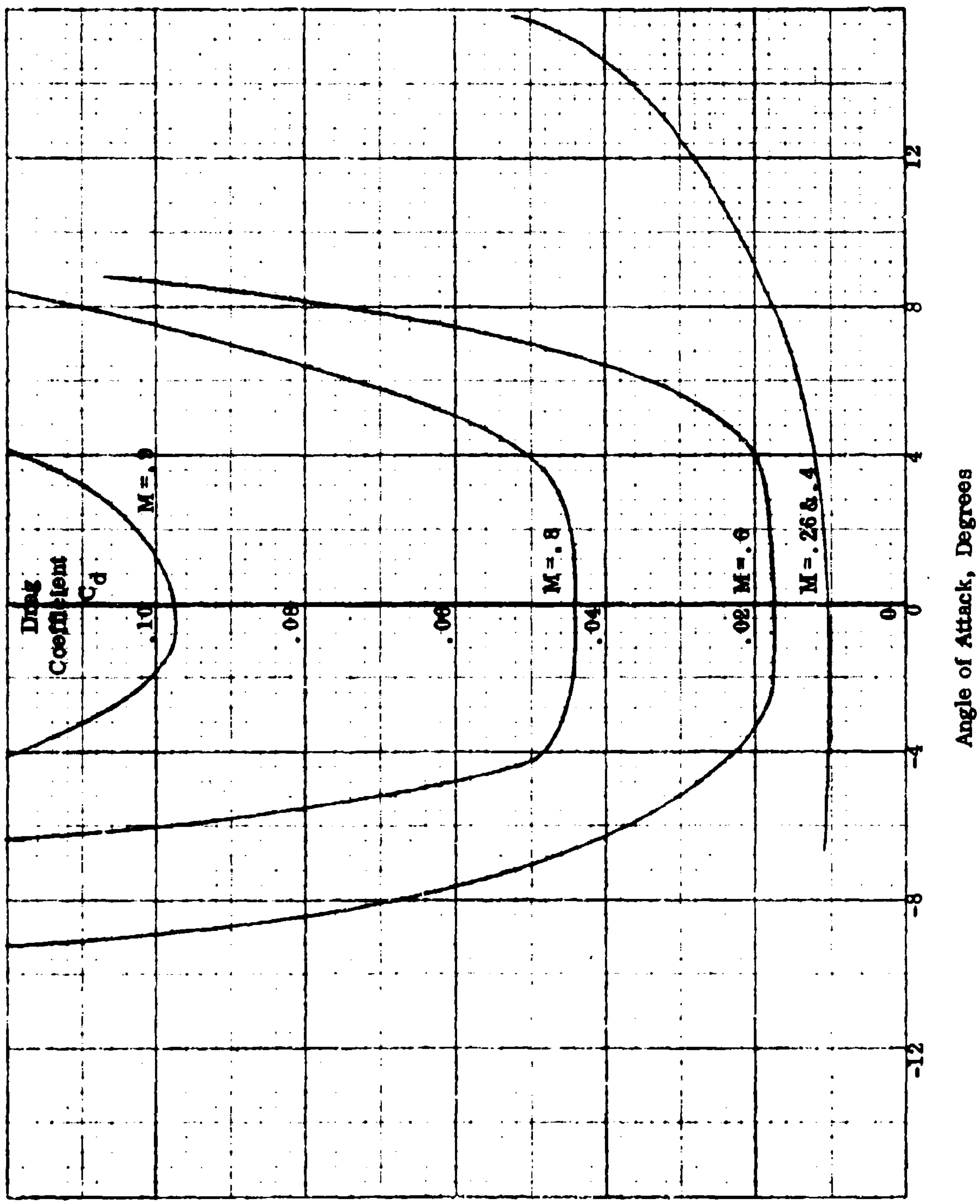

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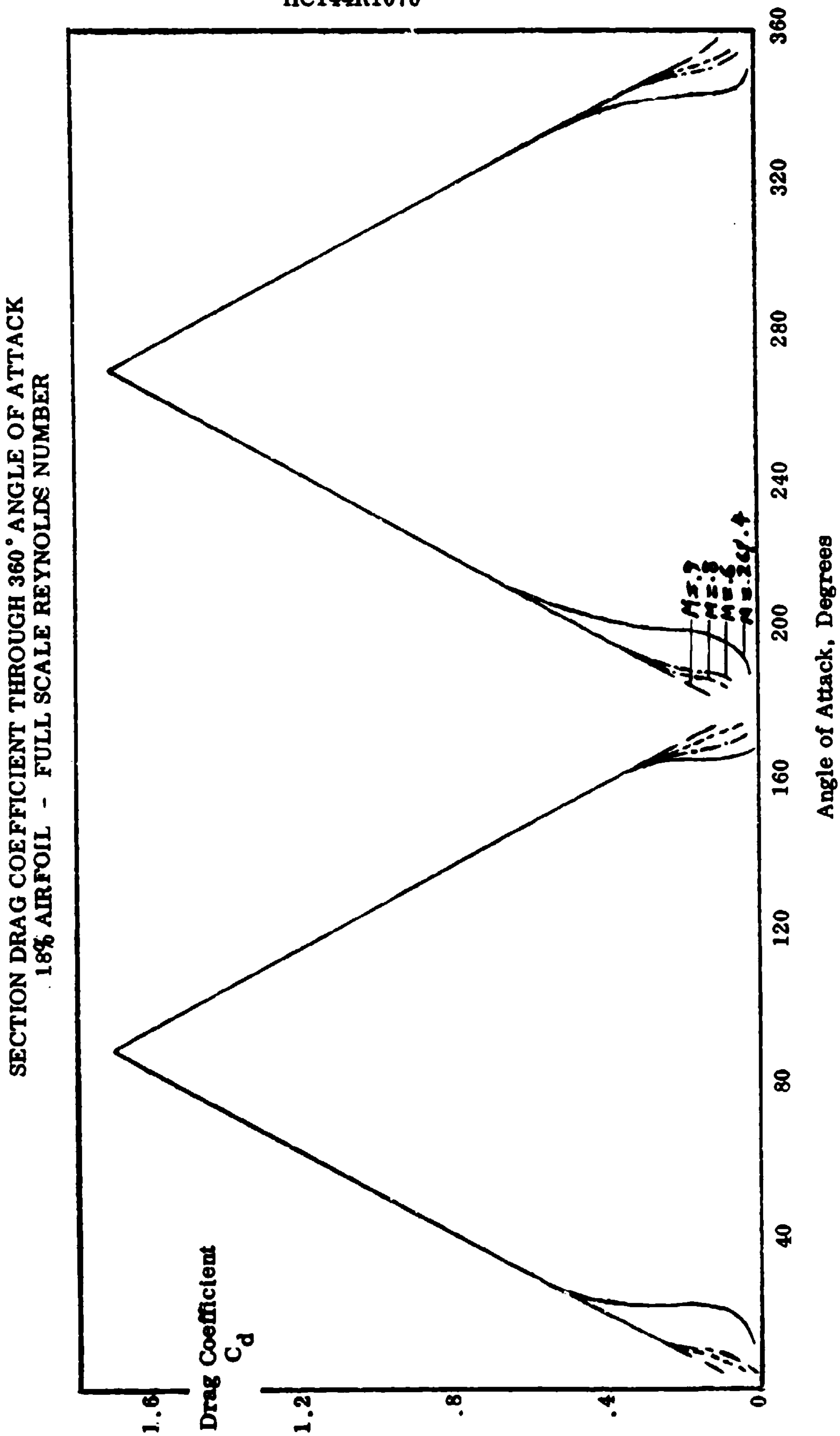
Figure D.36



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13. ABSTRACT

A one-seventh scale model reverse velocity rotor system was manufactured and tested with the goal of substantiating the results that had been predicted for this system in previous analytical studies. The 8 ft diameter 4 bladed hydraulically powered model rotor was provided with remote operation of the controls and shaft angle. Tests were conducted in the 12 ft pressure wind tunnel at NASA Ames during June and July 1972. The tests did not cover the whole range of conditions desired, but results were obtained at advance ratios from 0.3 to 2.46 and at tunnel speeds up to 350 knots.

Significant results of the tests were the freedom of the rotor from instability, and the ability to trim the rotor laterally and longitudinally under all conditions. Reasonable agreement was found between the measured performance of the model rotor and that predicted using the results of two-dimensional wind tunnel tests made on three reversible airfoil sections of the model rotor blade.

It is recommended that further tests be performed with this model to expand the envelope of test conditions, particularly to include testing with two-per-rev control angle input.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Reverse Velocity Rotor						
Reversible Airfoil-Rotor Blade						
Two per Rev Pitch						
Radial Flow						
Reverse Flow						
Lift to Drag Ratio						
High Advance Ratio						
High Speed Helicopter						
Helicopter Two per Rev Control System Mechanism						
Rotor Blade Stability						
Rotor Control						
Rotor Dynamics						
Model Rotor Wind Tunnel Test						
Airfoil Wind Tunnel Test						
Predicted Rotor Performance						